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SURGICAL BONE GRAFTING WITH "OS PURUM", "OS NOVUM", AND "BOILED BONE" *

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Instead of the commonly used fresh autoplastic bone graft, I have employed three other forms of grafts which I have called "os purum", "os novum", and "boiled bone". Each of these has its special range of use, its advantages, and its disadvantages. My use of these materials in the clinic gradually evolved during several years of experimental work on this subject. The results of these studies may be found in my previous publications. (See Bibliography.) I wish here briefly to describe these materials and to summarize the end results which I have obtained with their use.

Os purum is bone which has been freed of fat, connective tissue, and proteins by means of a lengthy physicochemical process, but it is not freed entirely of all the collagenous matrix. Bone obtained from a slaughter house, or occasionally from amputation specimens, is first mechanically freed of the surrounding soft tissues. The bone ends are then sawed off. The protein (blood protein, etc.) is extracted by soaking the bone in salt solution; the connective tissue on the bone surface and in the haversian canals is removed by soaking in warm potassium hydroxide; and the fat is extracted by soaking in acetone. The bone canals are carefully irrigated between the various processes. By means of this cleansing procedure, the bone canals are emptied and are thus free to admit the tissue fluids and the tissue cells growing in after implantation. Various shapes of os purum are shown in Figure 1.

Os novum, in contradistinction to os purum which is composed of the calcium framework of dead bone, is immature living bone tissue with great proliferative power. It is produced by implanting a long, narrow os-purum splint of suitable shape subperiosteally over the anteromedial

* Read at the Annual Meeting of the American Orthopaedic Association, Lincoln, Nebraska, June 3, 1937.

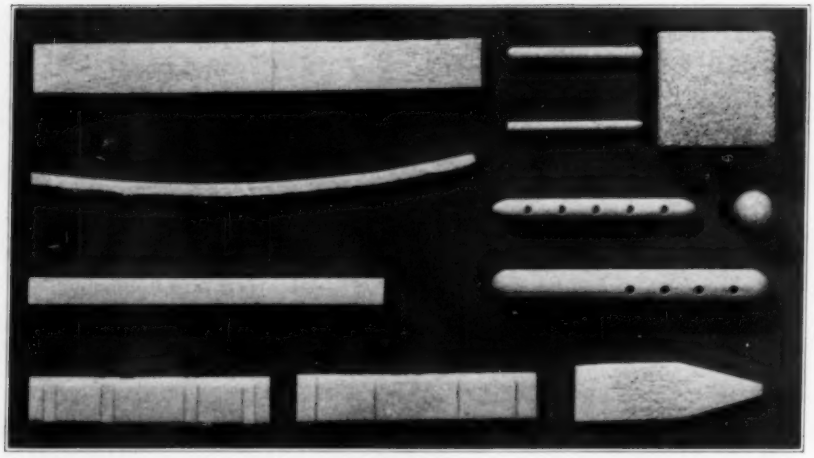


FIG. 1

Various forms of os purum compactum and os purum spongiosum. (*Courtesy of Aktiebolaget Pharmacia.*)

surface of the tibia. This procedure is shown in Figures 2 and 3. When the material is excised from one to two months later, a profuse growth of

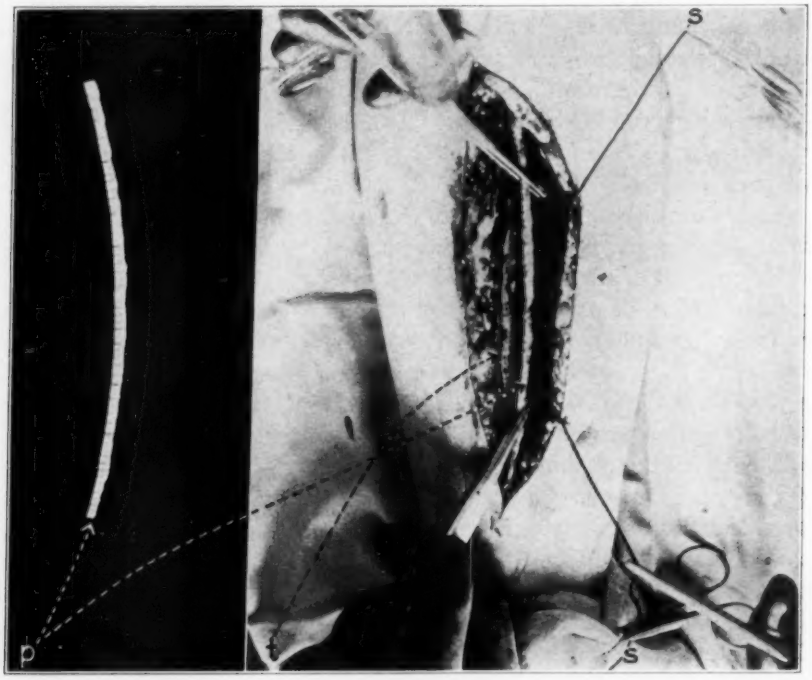


FIG. 2

Subpericsteal implantation of os purum over the anteromedial surface of the tibia. The sutures in the medial periosteal flap are indicated by *s*, the tibia by *t*, and the os purum by *p*. (*Courtesy of Acta Societatis Medicorum Suecanae and of Vromant & Co.*)

new, soft, vascular bone is found in the clefts between the periosteum, the os purum, and the tibia. (See Figure 4.) This new bone, which I have called os novum, is excised with a special bone spatula and then transplanted to the desired place.

Boiled fresh bone differs from os purum in that it contains fat, connective tissue, and proteins. I should like to point out that boiled bone which has been dried behaves in quite a different way than does fresh boiled bone. When boiled and dried bone is used for grafting, its resorption and the growth of new bone proceed very slowly and much less satisfactorily than when fresh boiled bone is used.

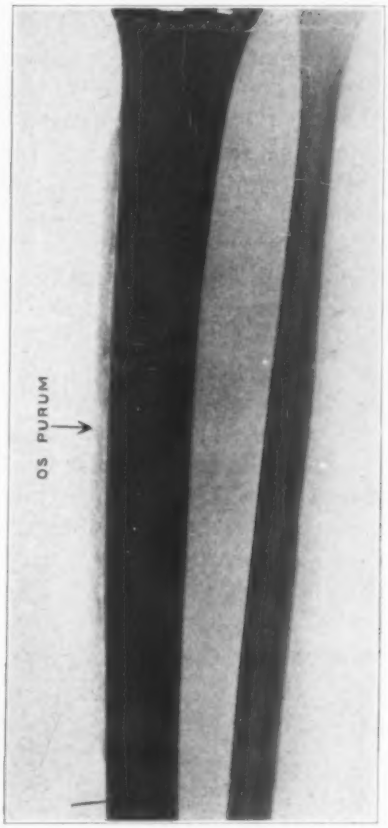


FIG. 3

Roentgenogram of os purum forty-two days after subperiosteal implantation over the tibia. The ends of the os-purum splint are sharpened, so that they may be inserted under the periosteum more easily. (*Courtesy of Acta Societatis Medicorum Suecanae and of Vromant & Co.*)

I have discovered in my experimental studies that a great deal depends upon the manner in which the living connective tissue transplanted with the bone reacts after the implantation, as well as upon the reaction of the connective tissue in the bed of the graft. The deep layer of the periosteum and the endosteum, as well as the connective tissue in the haversian canals, which I have termed collectively "skeletal connective tissue", is phylogenetically and ontogenetically assigned to bone formation, and reacts to stimulation from the calcium framework of an implant by forming new bone within fourteen days after the implantation. On the other hand, the connective tissue lying outside the skeleton, which I have called "extraskeletal connective tissue", is phylogenetically and ontogenetically assigned to collagen formation, and can only with difficulty be induced to form bone through the stimulation by the calcium of the implant. It requires a long time before the influence of the calcium framework of the graft is able to initiate this process, and it is not until at least three months after implantation that a slight formation of new bone becomes manifest. I have demonstrated this by implanting small fragments of boiled bone subcutaneously. Furthermore, in order that the new bone may endure, it is necessary that it take part in the bone physiology. Otherwise it will be resorbed together with the calcium framework of the implant.

CLINICAL EXPERIENCES WITH OS PURUM

When using implants in the skeleton—that is, in places containing skeletal connective tissue—os purum may be employed. This connective tissue proliferates and quickly forms a large amount of new bone in the clefts between the implant, the fixed bone in the bed, and the periosteum, and grows into the open haversian canals of the os purum. Complete resorption of the os purum and its replacement by new bone proceed slowly, however, and may take two or three years for completion, but from clinical experience I have learned that the mechanical support furnished by the graft during the period of reconstruction is sufficient to prevent collapse until the new bone is developed and is able to take over the supporting function.

I have used os purum for implantation in about fifty cases in which bone has been resected for various reasons (most often for tuberculosis) in order to fill the defects, to lessen the risk of deformities, and to fix skeletal parts to one another. In cases in which the skin was intact and the disease process was in a quiescent stage, these implants underwent reconstruction without complications. When abscesses or fistulae were present, the implant was often extruded.

A brief summary of the cases in which os purum has been used, together with roentgenograms of representative cases, follows.

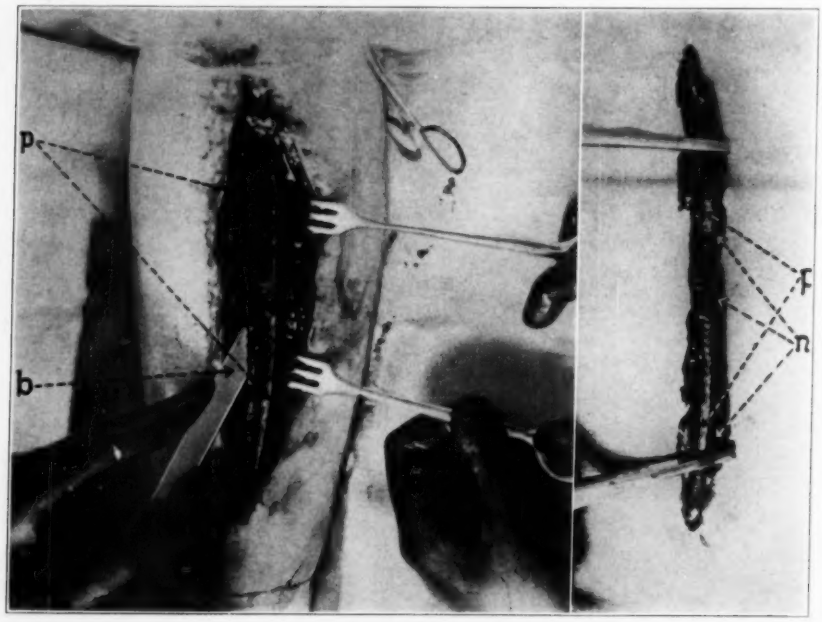


FIG. 4

Excision of the subperiosteal os purum and os novum from the tibia. The operative procedure is shown on the left and the excised specimen on the right: p = os purum; n = os novum; b = a specially made bone spatula used to free the os novum from the surface of the tibia. *(Courtesy of Acta Societatis Medicorum Suecanae and of Vromant & Co.)*

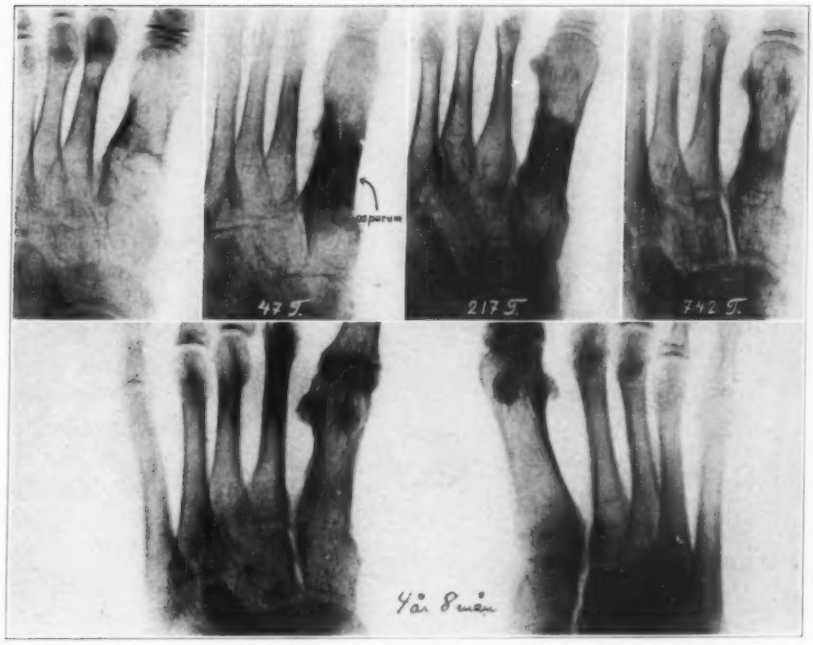


FIG. 5

Tuberculous osteitis in the first metatarsal bone of a boy eleven years old. On June 29, 1931, the lesion was scraped out and the bone was resected. The resected bone was replaced by os purum of similar shape, with primary healing. Eleven weeks after the operation the plaster cast was removed, and five months after the operation the patient was up and walking with shoes on. Good functional and anatomical results were obtained. The roentgenograms show the condition before operation, 47, 217, and 742 days after operation, and four years and eight months after operation. (*Courtesy of Acta Societatis Medicorum Suecanae.*)

Os purum was used in four cases of extra-articular tuberculous osteitis in the bones of the hands or the feet. Primary healing occurred in each case. The patient was usually able to discard his cast and, in the cases involving the feet, to get up two to three months after operation. The grafts were completely reconstructed in from one and one-half to two years after operation. Good anatomical and functional results were obtained in all cases. (See Figure 5.)

Of eight cases of tuberculous osteitis of the small bones of the hands and the feet with involvement of the neighboring joints, good results after grafting were obtained in all but two cases in which fistulae were present before operation. In one case, also, there was an exacerbation of pulmonary tuberculosis, and death occurred in another from pulmonary embolism. The roentgenograms in the latter cases showed marked resorption of the os purum without visible signs of new bone formation.

I have used os purum in three cases of para-articular lesions about the knee joint,—one case with a bone cyst, one with osteitis fibrosa, and one with tuberculous osteitis. There was primary healing in all. The reconstruction was good from one and one-half to two years later, and the

FIG. 6

Posterior and lateral roentgenograms of the left knee joint of a woman, twenty-one years old, 193 days after resection of the knee joint for tuberculosis and implantation of a wedge of os purum compactum. Primary healing occurred. The patient was up and about with a plaster cast two months after operation. The cast was discarded six months after operation.

Similar operations have been performed in eighteen cases in adults, all with good results. (*Courtesy of Acta Chirurgica Scandinavica.*)

anatomical and functional results were all good.

In two other cases of para-articular tuberculous lesions in which os purum was used—one in the acetabulum and femoral head, the other in the os pubis—good results were obtained.

In thirty-one cases of tuberculosis of the joints of the foot, the knee, or the shoulder, os purum was used as a graft to fill up bone defects after resection or to establish osteosynthesis. (See Figure 6.) Primary healing occurred in all the cases. It is interesting to note that when pieces of cancellous os purum were implanted to replace the bone removed at foot-joint resections, they were well able to withstand the great pressure to which they were subjected and underwent complete reconstruction without roentgenographic evidence of collapse. (See Figures 7-A and 7-B.) In only one case of tuberculosis of the foot joint, in which fistulae were present before operation, reconstruction was delayed and the healing was not primary.

Finally, os purum was used in an osteoplastic cuneiform osteotomy of the lower leg, and a good result was obtained. The danger of pseudarthrosis in such cases is great, however, and may necessitate the use of os novum.

CLINICAL EXPERIENCES WITH OS NOVUM

In instances in which extraskeletal connective tissue separates two bones which are to be joined through transplantation, living-bone implants such as os novum, not dead os purum, should be employed. Examples of this use are: osteosynthesis of the spinous processes in tuberculosis of the vertebrae, arthrodesis in iliosacral tuberculosis or tuberculosis of other joints, osteosynthesis in pseudarthrosis, arthroplasty, etc.

I have used os novum for the osteosynthesis of the spinous processes of the vertebrae in about sixty cases, with good results to date. (See

Figure 8.) The transformation of the new bone formed after the implantation of os novum proceeds more uniformly than is the case after the transplantation of fresh mature bone, probably because calcium-containing necrotic bone prevents the formation of new bone. The newly formed splint is firm throughout. Weak areas or defects do not appear as readily as after the transplantation of mature fresh bone, and consequently fractures do not occur. No real fracture of os novum has been observed in any of the cases operated upon to date.

Os novum has been employed for arthrodesis in four cases of tuberculosis of the sacro-iliac joint, with good results in all cases. From three to four months after operation, the patients were up and about and without complaints.

I have used os novum for osteosynthesis in eleven cases of pseudarthrosis with good results. (See Figure 9.) In these operations I have not, as a rule, excised the soft tissues of the pseudarthrosis. Os novum has been laid down in longitudinal strips like periosteal callus around the pseudarthrosis. The external fixation of the pseudarthrosis with casts or splints during the healing period is very important, and the duration of the fixation varies considerably according to the type of case. I hope to be able to report on this aspect in more detail at a later date.

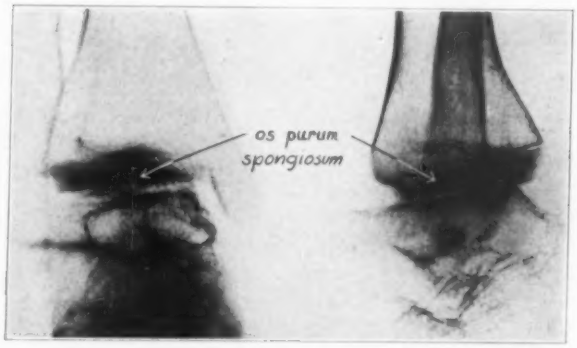


FIG. 7-A

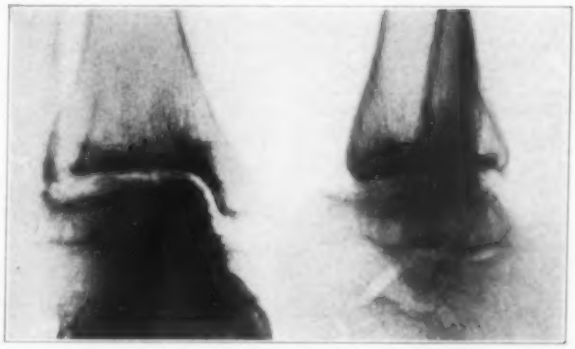
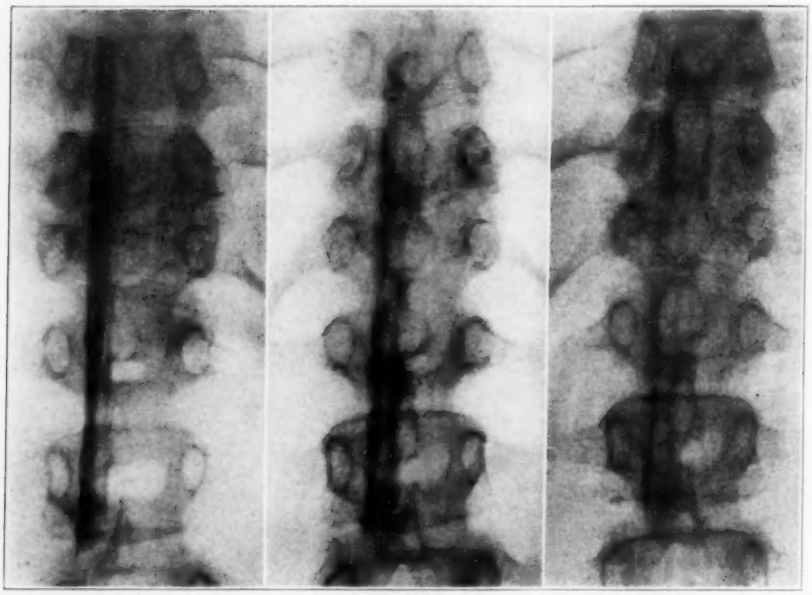


FIG. 7-B

Tuberculosis of the ankle joint of a male, seventeen years of age. Posterior and lateral roentgenograms of the right foot fifty-seven days (Fig. 7-A) and 643 days (Fig. 7-B) after resection of the ankle joint and replacement of the resected bone by a disc of os purum spongiosum. Primary healing took place. The patient was up and walking with a plaster cast three months after operation and has since worked for several years in a lumber yard.

Similar operations have been performed in eight other cases of tuberculosis of the ankle joint, with uniformly good results. (*Courtesy of Nordisk Medicinsk Tidskrift.*)

I have also employed os novum in two cases for so-called semiarthroplasty—that is, in arthroplasty of one joint surface when the opposite joint surface is healthy—but these cases need a longer follow-up period before the results may be fully evaluated.



81 days 300 days 629 days

FIG. 8

Tuberculous spondylitis in a boy of twelve years. A subperiosteal implantation of os purum over the tibia was done on September 13, 1932, followed by an osteosynthesis on November 11, 1932. Os purum and os novum were transplanted from the tibia to the split spinous processes of the vertebrae. The roentgenograms show the vertebrae 81, 300, and 629 days after operation. Primary healing occurred. The patient was able to walk with a corset the fourth month after operation. Good functional and anatomical results were obtained. The os purum, rich in calcium, is resorbed, while the os novum gradually acquires the same density and structure as the adjacent vertebrae. (*Courtesy of Acta Societatis Medicorum Suecanae and of Vromant & Co.*)

CLINICAL EXPERIENCES WITH BOILED BONE

I have also used boiled bone which, though not ideal, often has the proper shape and structure for replantation. I have used it when the bone is in a pathological condition—in chronic osteomyelitis, in bone tumors, etc.—when it has not been so easy to use os purum or os novum. I have then resected the diseased bone, boiled it in a physiological salt solution to kill the bacteria or tumor cells, cleared it of the diseased tissue masses, and replanted it to give mechanical support until new bone had been developed, at the same time using it as a stimulant to the living connective tissue in the bed.

I have treated four cases of chronic osteomyelitis with resection and replantation of boiled bone. Satisfactory results were obtained in all four cases. The healing usually took from six months to one year, with sequestration of a part of the replanted bone, but, in spite of this, the patients were up and about in from three to six months after the operation. There were no recurrences. One of these cases is shown in Figure 10.

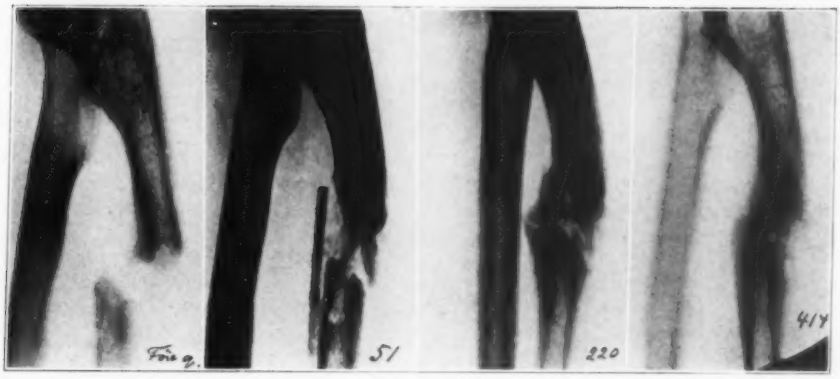


FIG. 9

Lateral roentgenograms of the right forearm before operation and 51, 220, and 414 days after operation for pseudarthrosis in the right ulna, following a compound fracture of the forearm sustained during an accident in May 1933. The patient was a fifty-year-old farmhand. On January 7, 1935, the interposed tissue was excised and the space between the ends of the bones was filled up as completely as possible with os novum. Several os-purum splints were implanted subperiosteally. Primary healing occurred despite thin, friable, and scarred skin. There was good consolidation seven weeks after operation. The patient has been working daily as a laborer since January 1936.

Os novum has been transplanted in the same manner in ten other cases of pseudarthrosis, with good results. (*Courtesy of Acta Societatis Medicorum Suecanae.*)

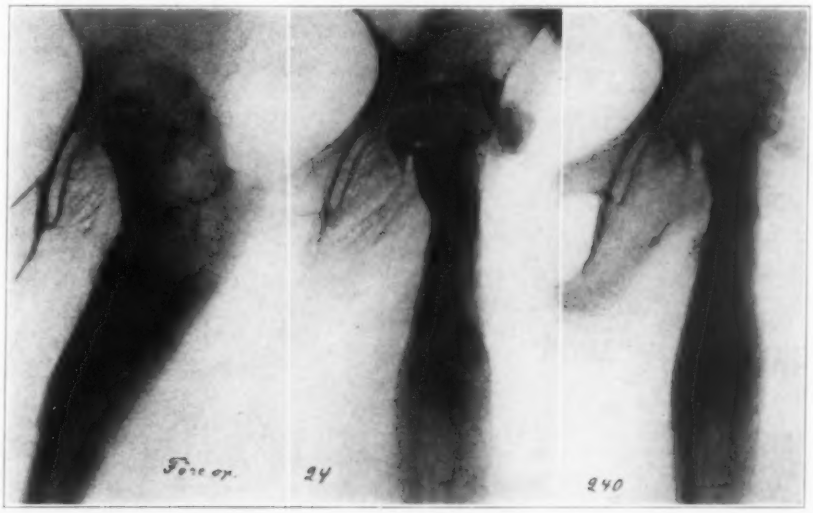


FIG. 10

Chronic osteomyelitis in the left femur of twelve years' duration in a woman, twenty-five years of age. On September 12, 1935, an osteotomy through the neck of the femur was performed. The diseased superior portion of the femur was freed and brought out through the wound, boiled for ten minutes in physiological salt solution, cleaned of necrotic bone, and replaced. Primary healing occurred. The patient was in bed for three months, then up and about with a plaster cast. Abscesses appeared in the soft parts twice after operation. She has since been well. The roentgenograms show the condition before operation and 24 and 240 days after operation. (*Courtesy of Acta Societatis Medicorum Suecanae.*)

This method has also been used in one case of malignant periosteal osteogenic sarcoma in the upper end of the humerus. (See Figure 12.) This case may be sufficiently interesting to justify a more detailed report.

The patient, a boy, sixteen years of age, had had symptoms since April 20, 1935. On August 8, 1935, a subperiosteal resection of two-thirds of the humerus and exarticulation of the shoulder joint were performed. The resected bone was boiled for from fifteen to twenty minutes; the tumor masses were scraped away; and multiple perforations were made in the bone to facilitate its resorption. The bone was then replanted.

Two months after the operation consolidation had taken place and the patient was up and about. Three months after the operation the cast was discarded. On December 29, in the fourth month after the operation, a spontaneous fracture was discovered in the replanted portion of the humerus. The patient had a good range of movement in the shoulder joint. There was no local recurrence, but a metastasis developed in the base of the right lung in October 1936. The patient died on November 26, 1936, fifteen and one-half months after the operation.

The pathological diagnosis of the tissue removed at operation was "an unusual form of telangiectatic chondro- and osteoplastic sarcoma". No recurrence in the humerus or in the soft parts of the upper arm was found at post-mortem examination.

This case is interesting in that there was no local recurrence during the fifteen and one-half months during which the patient lived after operation. This may be related to the fact that this was an unusual type of sarcoma. It is unfortunate that the pulmonary metastasis occurred, and it is possible, of course, that there would have been no metastasis if the patient had been operated upon earlier. Something has been gained, however, if local tumor necrosis or recurrence may be avoided in this way.

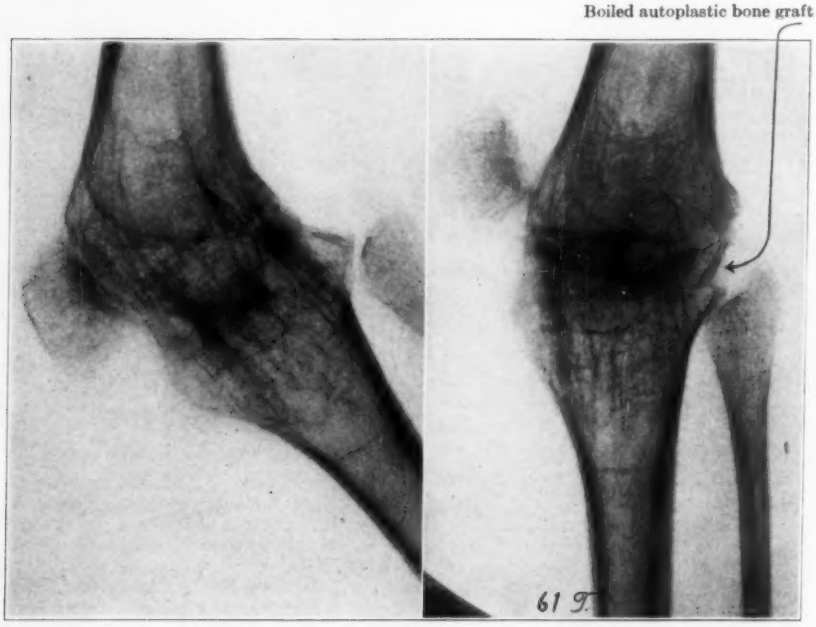


FIG. 11-A FIG. 11-B

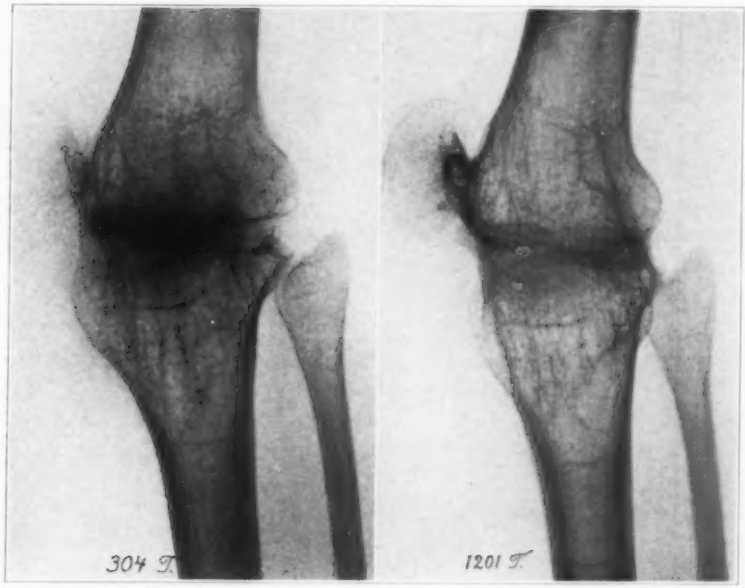


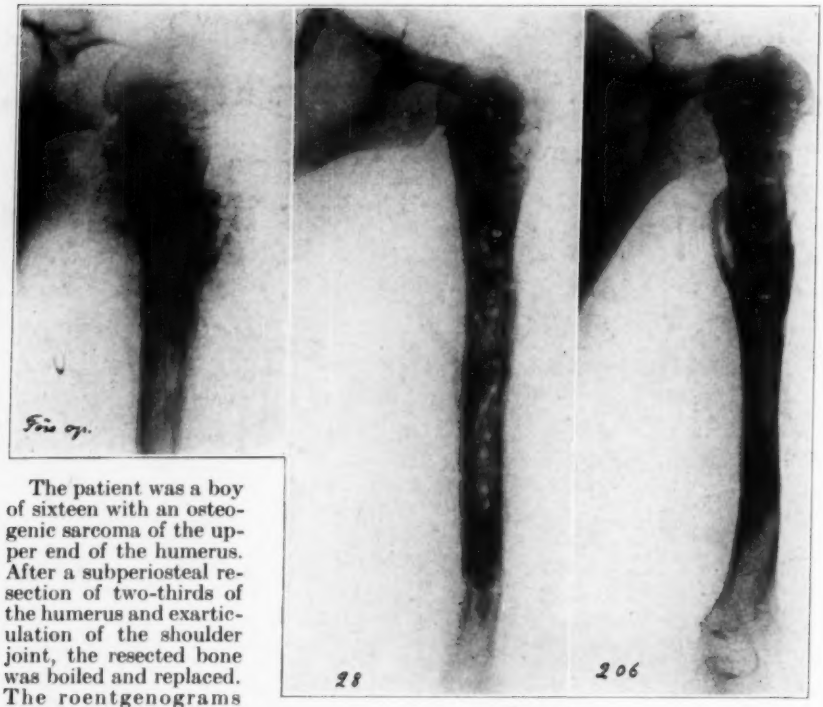
FIG. 11-C FIG. 11-D

Healed tuberculosis of the knee joint with ankylosis in pronounced flexion in a twenty-year-old woman. On May 9, 1930, an "osteoplastic cuneiform osteotomy" was performed. The bone wedge, which during the operation was accidentally touched with a non-sterile object, was boiled for ten minutes in physiological salt solution and replanted, after having been rotated 180 degrees. Primary healing occurred. The patient was up and about wearing a plaster cast nine weeks after operation. Good anatomical and functional results were obtained. The roentgenograms showed increased density and decreased distinctness in structural detail in the bone wedge until about 300 days after the operation. The density then began to decrease gradually, while the bone structure became increasingly evident. About 1000 days after operation, the bone fragment had been entirely replaced by new bone. The patient has been under observation for seven years since the operation. The roentgenograms show the condition before operation and 61, 304, and 1201 days after operation. (*Courtesy of Acta Chirurgica Scandinavica.*)

DISCUSSION

The study of bone-grafting teaches us that the bone should be considered as a tissue, the survival of which, like other living tissues, is dependent upon good nutrition. Every effort should be made to favor the nutrition of the soft tissues about the surface of the fixed bone in the operative field. The periosteum should not be separated from the soft parts lying outside, and the connective tissue in the haversian canals should not be injured through damage to the nutrient vessels. The instruments should be as small as possible and produce the least possible trauma. Experience has taught that the best method of exposing the bone is to loosen the periosteum from it. Nothing is gained by traumatizing the tissues lying external to the periosteum.

The use of these grafts, like that of fresh autoplastic material, requires a strictly aseptic procedure. The skin should be cleaned and washed with alcohol every day for at least three or four days before operation. After



The patient was a boy of sixteen with an osteogenic sarcoma of the upper end of the humerus. After a subperiosteal resection of two-thirds of the humerus and exarticulation of the shoulder joint, the resected bone was boiled and replaced. The roentgenograms show the upper arm before operation and 28 and 206 days after operation.

FIG. 12

(*Courtesy of Acta Societatis Medicorum Suecanae.*)

operation, the affected parts should be fixed in a plaster cast. A window should be cut over the wound so that it is accessible to the influence of air and light. As a rule, fixation for two or three months is necessary.

The surgical production of os novum shows that the bone-forming cells of the skeletal connective tissue grow most quickly and abundantly into the tissue-free clefts between the periosteum, graft, and bone after preliminary hematoma formation (blood, fibrin, tissue fluids). However, it is not desirable to have the hematoma formation so excessive that the newly formed skeletal connective-tissue cells are unable to penetrate the mass.

The soft and vascular osteoid and newly formed skeletal connective tissue of os novum readily absorbs nutrition and forms new bone. Because of its softness, it can be shaped easily and without injury to fit the new bed, and it is better tolerated by the soft tissues than is fresh, mature, hard bone. Scarred, eczematous skin, for example, which is often present over a pseudarthrosis, does not seem to be so greatly irritated by os novum as by hard bone.

At first, os novum gives only slight mechanical support, and cannot, therefore, be used for the internal fixation of bone parts. Since it is easily nourished and has great proliferative power, it is suitable for cases in

which rapid new bone formation is desired, and where fresh material should not be taken from the skeleton itself, as, for example, in children with delicate bony framework. If increased internal fixation is desired, a combination of os purum and os novum may be used.

Os purum has a technical advantage in that it can be kept on hand in a dry form and sterilized by the usual heating methods, preferably by boiling in physiological salt solution. This dissolves a part of the collagenous gluelike material, thereby making the material softer and easier to handle. It may be obtained in various sizes and can easily be given the desired shape with the help of hand- and motor-driven tools.

I have repeatedly demonstrated that all three types of grafting material described can be used to advantage in various surgical procedures. I have been able here only to describe very briefly a few ways of employing these new grafting materials and the principles governing their use. It is, of course, as yet impossible fully to evaluate these materials. It will take much time and work before we can determine in detail exactly when and how to use them. I hope that research along this line will provide us with increased knowledge of the nature of bone formation to the benefit of bone surgery and surgery of the extremities in general.

BIBLIOGRAPHY

ORELL, SVANTE: Experimentalchirurgische Studie über Knochentransplantate und ihre Anwendung in der praktischen Chirurgie. (Vorläufige Mitteilung.) Deutsche Ztschr. f. Chir., CCXXXII, 701, 1931.

"Osteoplastic Cuneiform Osteotomy" in the Treatment of Ankylosis. Report of Two Cases. J. Bone and Joint Surg., XIV, 643, July 1932.

Osteosynthesis by Interposition of Transplanted Bone. Acta Orthop. Scandinavica, IV, Fasc. 1, 1933.

Studien über Knochenimplantation und Knochenneubildung, Implantation von "os purum" sowie Transplantation von "os novum". Acta Chir. Scandinavica, Supplementum XXXI, 1934.

Interposition of Os Purum in Osteosynthesis after Osteotomy, Resections of Bones and Joints (Interposition-Osteosynthesis). Surg. Gynec. Obstet., LIX, 638, 1934.

Knochentransplantation. Lennander-Vorlesung. Acta Societatis Medicorum Suecanae, LXII, 107, 1936.

Transplantation of "os novum". *In* Livre jubilaire offert au Dr. Albin Lambotte. Bruxelles, Vromant & Co., 1937.

THE INFECTIOUS ORGANISM IN OSTEOMYELITIS *

PART I. THE BACTERIOLOGY OF BONE INFECTION †

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On February 14, 1880, the eminent orthopaedic surgeon, Lannelongue, invited Louis Pasteur to be present at the Hôpital Sainte-Eugénie while he operated on a girl of twelve years, who presented a closed swelling of the right leg, knee, and lower thigh. A long incision released abundant pus. The tibia was found to be denuded over a long stretch. Three openings made in the bone released pus welling up from each. Samples of pus taken by Pasteur himself from all of these sources showed under the microscope packets of the microbe of furuncle and from each sample were grown cultures typical of the microbe of furuncle. In this case, therefore, the osteomyelitis was essentially a furuncle of bone and bone marrow. In reporting this pioneer observation, Pasteur suggested that it should be easy to produce osteomyelitis experimentally in living animals.

Rosenbach, Becker, and Feodor Krause confirmed this observation. Becker injected the microbe, which we now call staphylococcus aureus, intravenously into experimental animals in which he fractured or contused the bones and was able in this way to produce suppuration of bone at the site of injury. Krause also succeeded in producing bone suppuration in rabbits and guinea-pigs by a similar technique. He has described the lesions of other tissues observed in these experimental animals, in particular the very frequent renal abscesses in the rabbit, and the occasional suppurating joints. This careful observer concluded that the disease which he produced experimentally resembled the pyaemia of man rather than the common typical human osteomyelitis.

Rodet, in 1884, was the first to produce, by experimental intravenous injection of staphylococci into young rabbits, without physical trauma, the juxta-epiphyseal necrotic and suppurative lesions of bone, so analogous to those of human hematogenous osteomyelitis as to be accepted as essentially the same. Confirmatory studies by many subsequent investigators have confirmed Rodet's findings and have established the fact that osteomyelitis is most commonly due to infection with staphylococcus aureus. However, other bacteria are at times concerned in the infection of bone. The work of Lannelongue and Achard may be mentioned especially in this connection. At present we may say that the yellow staphylococcus is the microbic cause of more than half the cases of osteomyelitis,

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Cleveland, Ohio, January 12, 1937.

† Aided in part by a grant from the Josiah Macy, Jr. Foundation.

while an appreciable number of cases are caused by the staphylococcus albus, the streptococcus hemolyticus, the pneumococcus, the typhoid and paratyphoid bacilli, the tubercle bacillus, and the spirochete of syphilis; very rarely, by other microbes as, for example, the meningococcus.

In general one may observe somewhat different clinical peculiarities in the course of the disease, depending upon the type of the infecting microbe. However, the variations in the clinical picture which may be observed in staphylococcic osteomyelitis alone are so marked and so confusing that the careful student will require bacteriological evidence for his decision. Garrè has given special attention to the exceptional forms of the disease and has shown that the yellow staphylococcus may cause an albuminous periostitis, a subacute osteomyelitis, a sclerosing non-suppurative osteomyelitis, a bone abscess which may heal spontaneously, a recidivous osteomyelitis after an interval of twenty years or more, and a primary osteomyelitis of adults, as well as the more common acute osteomyelitis of children. One should not neglect the opportunities for bacteriological study of these lesions, the results of which furnish an aid to prognosis and a guide to treatment.

The exact course of events leading up to the destruction of bone by the staphylococcus has not yet been fully ascertained, although considerable debate and some careful experimental study have been devoted to this matter. Pasteur, in 1880, pointed out that the staphylococcus appeared unable to grow in the circulating blood. When he injected it intravenously into guinea-pigs, the animals remained well and the microbes were eliminated from the blood or digested. However, he felt sure that the germs could be transported in the blood to a new site for development and he was of the opinion that cultures of the blood in cases of human staphylococcic infection, made by using several grams instead of drops of blood, would disclose the occasional presence of these microbes in the circulating blood.

Lexer, in a series of important papers, concluded that the localization of bacteria at certain places in bone depended upon trauma and upon structural features of the epiphysis associated with the active growth of bone. He was able to confirm the results of Rodet and of Lannelongue and Achard in experiments on young rabbits. Lexer thought that the purulent foci in the bone were of embolic origin, the embolus coming from thrombophlebitis at the primary site of infection, a view which was still accepted by Wilensky in 1934.

Josef Koch has shown that, in children dying of infectious diseases such as measles, diphtheria, pertussis, scarlet fever, or gastro-enteritis, the epiphyses of the bones quite regularly harbor streptococci, staphylococci, and colon bacilli and, occasionally, other organisms. By experimentation on mice and on young rabbits, he convinced himself that the localization of the bacteria at these sites was a result of favorable conditions for their survival and growth and was not to be explained by mechanical factors causing them to lodge there from the circulating blood. In

fact, the bacteria injected into the blood lodged in abundance in the bone marrow of the shaft, but in this location the microbes were destroyed, while they were able to survive at the epiphyses.

Several experimental investigators have challenged some of the ideas of Lexer. Especially important is the investigation of Hobo. He points out that pulmonary abscesses are absent in human osteomyelitis and usually absent in experimental osteomyelitis, and one might expect that infected emboli would be caught in the pulmonary capillaries before reaching the bones. He also exposes the fallacy of the mechanical theories. Foreign particles in the blood do not just settle where the current is slow, but they are actively phagocytosed in the spleen, the liver, and the bone marrow. Intravenous injection of India ink into rabbits caused the visible mucous membranes to become dark almost immediately, but these bleached out again in about ten minutes. When the animals were killed after forty-five minutes, the liver, the spleen, and the entire bone marrow were intensely black, while the other organs showed no macroscopic changes, although a few pigmented thrombi were found in them microscopically. In the liver, the spleen, and the marrow the ink particles were largely phagocytosed within the endothelial cells. In the marrow the capillary endothelium was full of ink particles, and wandering cells, lying on the capillary walls, were full of the particles. These ink deposits were always found in the venous capillaries and never in the terminal arterioles. Always the marrow of the metaphysis contained less ink than the marrow of the shaft. However, at the curve of the capillary loop in the metaphysis there were clumps of ink particles without efficient phagocytosis. These observations, which are in accord with those of J. Koch, Dumont, and Kusama, require the consideration of biological factors of tissue resistance rather than a mere mechanical explanation for the common localization of bacterial infection at the metaphysis of growing bone. It seems significant that the spleen, the liver, and the shaft marrow, in which early accumulation and phagocytosis of circulating foreign particles and bacteria are most abundant, are locations which escape the later abscesses, while the metaphysis of growing bone and the renal substance are the favorite sites for abscess formation.

These pathological and experimental observations are fundamental to an understanding of the course of events in the body of a patient with hematogenous osteomyelitis, and a clear understanding of their significance will aid the judgment of the physician in his decision in regard to treatment. The overwhelming invasion of the blood stream by virulent staphylococci from an active suppurating focus must be regarded as a general infection, in which the painful spot in a bone is merely one localization of minor importance,—a situation in which the patient is fighting for his life and will only be further depressed and endangered by ill-considered incisions and drillings. Radical operation upon children of this type is probably the most common serious error in the therapy of acute hematogenous osteomyelitis at the present time. When the infection of

the blood stream has been of a milder character, so that it has been overlooked and the suppurating lesion in the metaphysis has appeared following strain or local trauma or some other depressing experience, the infectious agent is usually of diminished virulence and the host resistance is relatively high. There is little real excuse for the panic which results in hasty, ill-considered operation on these patients. Considerable progress has been made in surgery since Murphy taught: "*In acute osteomyelitis operate it at once*" and "*But even if you should not find it* [*pus*] *there in an individual case you will have done the patient no harm by the mere trephining of the bone, and will have eliminated a source of worry for yourself.*" Starr did much to still the riot of radical surgery in this disease and the wise counsel of Dean Lewis gently but firmly favors conservatism. It is most significant that even younger men now dare to favor a less radical treatment of osteomyelitis in children. Thus Wilson and McKeever venture to say that survival of the patient may after all be a matter of some importance, that operative interference is often undertaken too early rather than too late, and that perhaps the answer to the problem is not the earliest possible surgical invasion of the bone, but a well-timed adequate drainage of the medullary canal when the individual's resistance is at the highest possible point. One also hears more frequent mention of the general factors of resistance to infection.

SUMMARY

1. Hematogenous osteomyelitis is due to the growth of bacteria which have reached the interior of bone by transport through the blood stream. Bacteria of various kinds may be concerned, but the staphylococcus aureus is responsible in most instances.

2. Localization of the disease process depends upon diminished resistance at particular sites, associated with growth activity at the metaphysis or with trauma at any place. In the absence of trauma, the marrow of the shaft is relatively resistant to infection because of the efficiency of its endothelial cells in the phagocytosis and destruction of bacteria.

3. A consideration of the bacteriological relationships indicates the wisdom of a conservative attitude in dealing with acute hematogenous osteomyelitis.

REFERENCES

BECKER: Die Mikrokokken der Osteomyelitis. Berliner klin. Wchnschr., XX, 816, 1883. Le microcoque spécifique de l'ostéomyélite infectieuse aiguë. Semaine Méd., III, 374, 1883.

DUMONT, F. L.: Experimentelle Beiträge zur Pathogenese der akuten hämatogenen Osteomyelitis. Deutsche Ztschr. f. Chir., CXXII, 116, 1913.

GARRÈ, C.: Ueber besondere Formen und Folgezustände der akuten infektiösen Osteomyelitis. Beitr. z. klin. Chir., X, 241, 1893.

HOBO, TERUO: Zur Pathogenese der akuten haematogenen Osteomyelitis, mit Berücksichtigung der Vitalfärbungslehre. Acta Scholae Med. Univ. Imp. in Kioto, IV, 1, 1921–1922.

Koch, Josef: Untersuchungen über die Lokalisation der Bakterien, das Verhalten des Knochenmarkes und die Veränderungen der Knochen, insbesondere der Epiphysen, bei Infectionskrankheiten. Ztschr. f. Hyg. u. Infectionskrankh., LXIX, 436, 1911.

Krause, Feodor: Ueber einen bei der acuten infectiösen Osteomyelitis des Menschen vorkommenden Mikrokokkus. Fortschr. d. Med., II, 221, 261; 1884.

Kusama, Shigeru: Über Aufbau und Entstehung der toxischen Thrombose und deren Bedeutung. Beitr. z. path. Anat. u. z. allg. Pathol., LV, 459, 1912–1913.

Lannelongue et Achard: Étude expérimentale des ostéomyélites à staphylocoques et à streptocoques. Ann. de l'Inst. Pasteur, V, 209, 1891.

Lexer, E.: Zur experimentellen Erzeugung osteomyelitischer Herde. Arch. f. klin. Chir., XLVIII, 181, 1894.

Osteomyelitis-Experimente mit einem spontan beim Kaninchen vorkommenden Eitererreger. Arch. f. klin. Chir., LII, 576, 1896.

Experimente über Osteomyelitis. Arch. f. klin. Chir., LIII, 266, 1896.

Zur Kenntniss der Streptokokken- und Pneumokokken-Osteomyelitis. Arch. f. klin. Chir., LVII, 879, 1898.

Murphy, J. B.: Murphy's Clinical Talks on Surgical and General Diagnosis. A Diagnostic Talk on Osteomyelitis. Clinics of John B. Murphy, IV, 187, 1915.

Pasteur, L.: De l'extension de la théorie des germes à l'étiologie de quelques maladies communes. Bull. de l'Acad. de Méd., IX, 435, 1880.

Rodet, A.-J.: Étude expérimentale sur l'ostéomyélite infectieuse. Compt. rend. Acad. des Sciences, XCIX, 569, 1884.

De la nature de l'ostéomyélite infectieuse. Production d'ostéites juxta-épiphysaires chez les animaux, par injection de liquides de cultures, sans traumatisme osseux. Rev. de Chir., V, 273, 1885.

Rosenbach, J.: Beiträge zur Kenntniss der Osteomyelitis. Deutsche Ztschr. f. Chir., X, 369, 1878.

Starr, C. L.: Acute Hematogenous Osteomyelitis. Arch. Surg., IV, 567, 1922.

Osteomyelitis. *In* Dean Lewis' Practice of Surgery, II, Chap. 2.

Wilensky, A. O.: Osteomyelitis: Its Pathogenesis, Symptomatology, and Treatment. pp. xxxii and 454. New York, The Macmillan Co., 1934.

Wilson, J. C., and McKeever, F. M.: Hematogenous Acute Osteomyelitis in Children. J. Bone and Joint Surg., XVIII, 328, Apr. 1936.

THE INFECTIOUS ORGANISM IN OSTEOMYELITIS *

PART II. BACTERIOPHAGE AND SERUM THERAPY †

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In the second part of this paper, the author wishes to mention briefly some of the general measures for combating infection in contradistinction to the local measures of incision and drainage. For some years we have been engaged in the study of the phenomenon of transmissible bacterial lysis and its possible application in the treatment of infections, and it is the purpose of this paper to discuss the bacteriophage phenomenon as we observe it in the bacterial culture, the technique of preparation of the material for use in animal experimentation and in human disease, the effect of these bacteriophage agents in animals, and their effects when administered intravenously to patients with osteomyelitis.

The mysterious destruction of cholera germs by the waters of the River Jumna at Agra, India, was recorded by Hankin in 1896, but there still remains some uncertainty in regard to the nature of the destructive agent. Twort, in 1915, observed the solution of bacterial colonies on solid media and was able to show that this transmissible dissolution of bacteria was caused by a filterable virus. Subsequently d'Herelle recognized the solution of cultures of the Shiga bacillus by a filterable agent, to which he gave the name of bacteriophage, and he has been able to extend these observations so as to recognize the phenomenon of transmissible bacteriolysis in many microbic species and to apply these observations in the treatment of diseases of animals and of men.

The bacteriophage phenomenon as observed in the laboratory is well illustrated by mass cultures on agar plates. For example, one may inoculate a solidified agar plate by spreading a broth suspension of the colon bacillus over the surface; then one adds a suitable amount of a potent bacteriophage filtrate to the broth suspension and inoculates a second agar plate by spreading this mixture over the surface. These two plates are then incubated together. After a suitable interval, if the mixtures have been fortunate, one is able to observe moth-eaten spots in the confluent growth of the second plate, while the first one shows the usual mass culture of bacterial growth. Such an experiment is illustrated in Figures 1-A and 1-B, which are taken from a previous publication of Miss Frances C. Frisbee of our laboratory. The phenomenon may also be illustrated on agar slants by drawing a wire wet with the bacteriophage along the center

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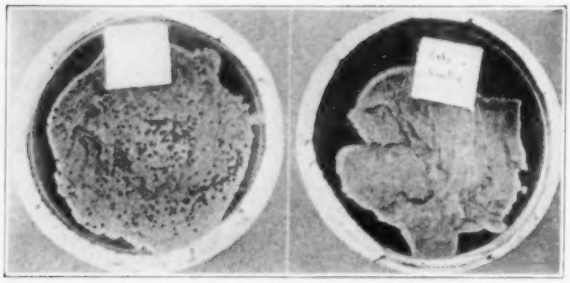

FIG. 1-A FIG. 1-B

The agar plate in Fig. 1-A was streaked with a bacterial suspension to which a small amount of bacteriophage had been added. The clear areas in the growth represent bacteriophage plaques. The agar plate in Fig. 1-B is a control plate streaked with the bacterial suspension to which no bacteriophage was added. (*Courtesy of Archives of Ophthalmology.*)[12]

of the slant after it has been inoculated with the susceptible bacteria. In liquid media, one obtains a sharp contrast because the culture tube inoculated with the bacteria alone becomes diffusely clouded, while that which has been inoculated with the bacteria and the bacteriophage begins to cloud and then becomes entirely clear as if no growth had ever taken place. Such cultures in liquid media serve not only to illustrate the phenomenon, but the cleared culture, when filtered, furnishes the usual bacteriophage preparation which is employed for further experimentation in laboratory cultures and in therapy. The changes taking place in the bacterial cells in such a dissolving culture have been studied by numerous observers and we know that the individual bacterial cell tends first to swell and then it quite suddenly bursts and passes into solution. Such swollen and disintegrating bacterial cells in a culture of Asiatic cholera subjected to bacteriophage lysis are illustrated in Figures 2-A and 2-B.

The effect of the bacteriophage in the internal tissues of the body is evidently somewhat different from the effect observed in the test tube. The swelling and bursting of the bacteria

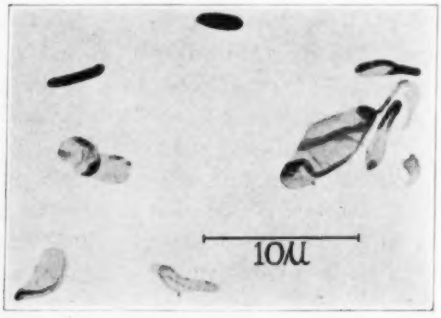

FIG. 2-A FIG. 2-B

Stained preparation of sediment from test-tube cultures of cholera germs incubated with cholera bacteriophage for four hours. The smallest bacteria represent the normal size and shape of the cholera germs. Note that many individuals are enormously swollen. In Fig. 2-B, many of them have absorbed water from the medium and are about to disintegrate completely.

have not been observed there. On the other hand, we have been able to show that the intravenous injection of potent bacteriophage into rabbits, subsequent to their intravenous inoculation with the susceptible bacteria, is followed by a more active and efficient phagocytosis of these bacteria by the endothelial cells of the spleen and liver and also by a more prompt intracellular digestion of these phagocytosed bacteria.[8] In the animals receiving the injections of bacteriophage there was a relative protection of the various organs from localization of the infectious agent. The appearance of endothelial cells of the liver in such experimental animals is illustrated in Figure 3. The effect of the bacteriophage in such instances is to aid the body defenses against the bacterial invader.

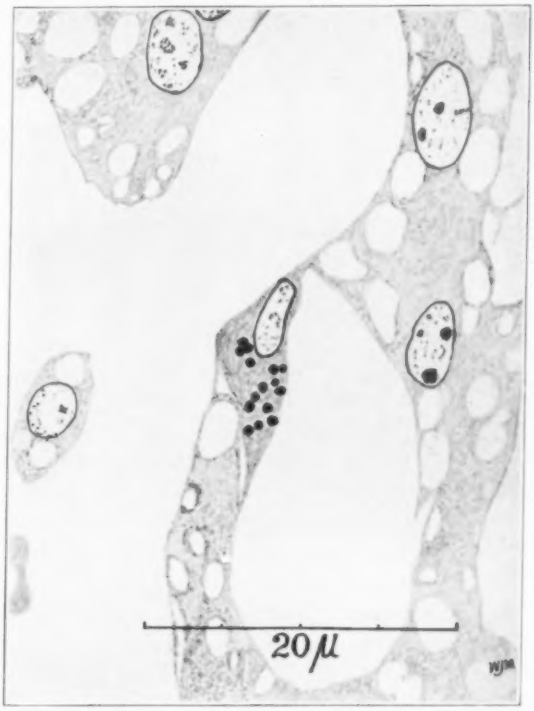

FIG. 3

Phagocytosed bacteria in an endothelial cell of rabbit liver fixed in the distended state after perfusion. This phenomenon of phagocytosis is favored by the presence of staphylococcus bacteriophage in the blood.

The effect of bacteriophage in the treatment of accessible local infections is exemplified by the treatment of carbuncles. Figure 4 shows the back of an infant who had enormous carbuncles on the buttocks. These were treated by needling with staphylococcus bacteriophage, with an excellent result. The picture was taken about two weeks after beginning the bacteriophage therapy. In another patient, L. S., a suppurating cellulitis of the left hand, with accumulation of pus in a bursa on the back of the hand, was treated by aspiration of the bursa and irrigation with

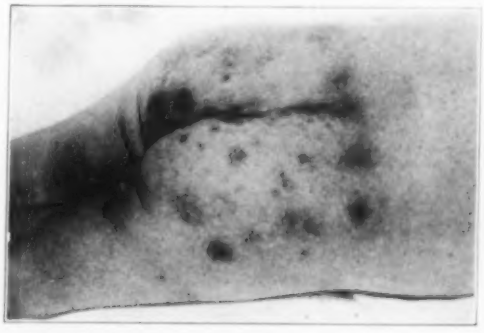

FIG. 4

Photograph of the buttocks of a baby, taken on May 22, 1931, after local bacteriophage treatment of enormous carbuncles from May 5 to May 12. (*Courtesy of New York State Journal of Medicine.*)[3]

FIG. 5-A

FIG. 5-B

Hands of L. S., photographed March 29, 1933. The site of most severe earlier inflammation is indicated by the thickened skin. On March 6, 1933, the patient presented himself with a fluctuating prominence surrounded by a swollen red area covering the dorsum of the left hand. Aspiration obtained thick hemorrhagic pus which, on culture, yielded staphylococcus aureus. On March 8, the cavity was again aspirated and irrigated six times with bacteriophage, and was left in the collapsed state. This treatment was repeated on March 10 and 13. On March 15, the cavity was punctured with two needles and washed through with six cubic centimeters of asparagin bacteriophage. This treatment was repeated on March 16, 17, 18, and 20. The fingers were fixed by a wooden splint until March 18, but after that time free movement was permitted. Cultures of the thin exudate obtained on March 20 remained sterile. The patient also received immunizing doses of one cubic centimeter of bacteriophage into the deltoid region on March 6, 10, 15, 22, and 25. He continued to work all the time, and the functional result has remained perfect. (*Courtesy of American Journal of Medical Sciences.*)[4]

staphylococcus bacteriophage during a period of eighteen days. As a result, the lesion healed without incision, deformity, or disability. Figures 5-A and 5-B illustrate the condition of the hands of this patient at the end of four weeks.

In our papers on staphylococcic septicaemia [5, 6, 7] we have presented summarized records of several patients in whom a septicaemia was associated with osteomyelitis. In general, the intravenous administration of the bacteriophage has exerted some influence in protecting the skeleton from metastatic localizations of the infection, but in those instances in which an operation had already been performed upon the bone the patients appeared not to do so well. In several instances we have had to deal with patients in whom there was an infection not only with the staphylococcus but also in combination with the hemolytic streptococcus. In such instances we have employed staphylococcus bacteriophage and a concentrated antistreptococcus serum to combat the double infection. One of these cases has been made the subject of a special report.[9]

The report of another patient with double infection is presented here.

E. F., male, aged eighteen months, came to the Hospital with a swollen and painful right wrist on April 21, 1935. The blood culture on admission was negative. On the next day, April 22, the wrist was incised and the incision was carried through the periosteum, releasing some exudate. Blood culture, taken a few hours after this operation, revealed staphylococcus aureus in the blood stream and the exudate from the operative incision also yielded the same organism. The clinical course of this little patient is illustrated in Figure 6. The dressings were displaced on April 24 so as to expose the

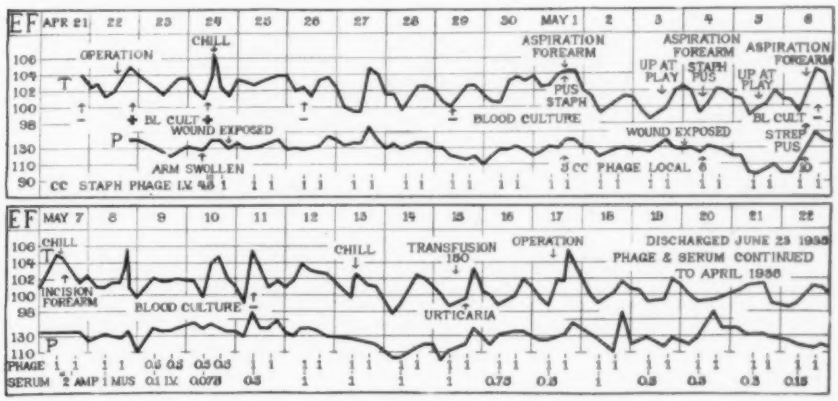

FIG. 6

Abbreviated clinical record of E. F., male, aged eighteen months. This baby was operated upon on April 22, 1935 by incision of the right wrist passing through the periosteum of the ulna. Immediately after the operation, blood culture was taken, which gave positive growth of staphylococcus aureus. Staphylococcus bacteriophage was administered intravenously beginning on April 24. Blood culture became negative forty-eight hours later. Secondary infection with streptococcus hemolyticus was recognized on May 6, and streptococcus serum was given along with the staphylococcus bacteriophage from May 7, 1935, to April 1936. The soft parts of the forearm were incised on May 7, 1935, for drainage. The child has made a complete recovery. (See Figs. 7 through 20.)

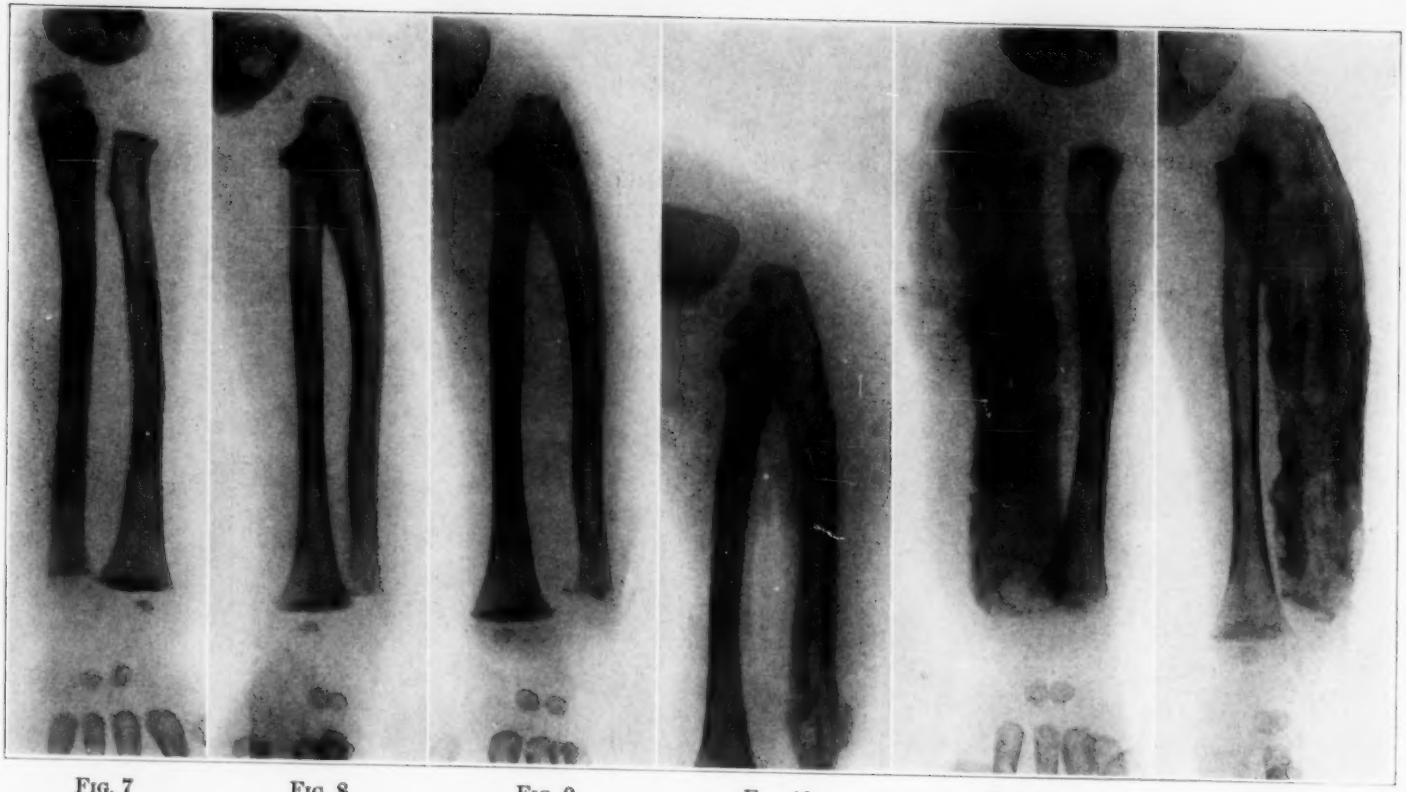

FIG. 7 April 22, 1935 | FIG. 8 April 22, 1935 | FIG. 9 April 27, 1935 | FIG. 10 May 7, 1935 | FIG. 11 June 7, 1935 | FIG. 12 July 9, 1935

A series of roentgenograms of the forearm of Patient E. F. The right wrist was incised on April 22, 1935, and the right forearm was incised on May 7, 1935. Note the progressive alteration of the ulna.

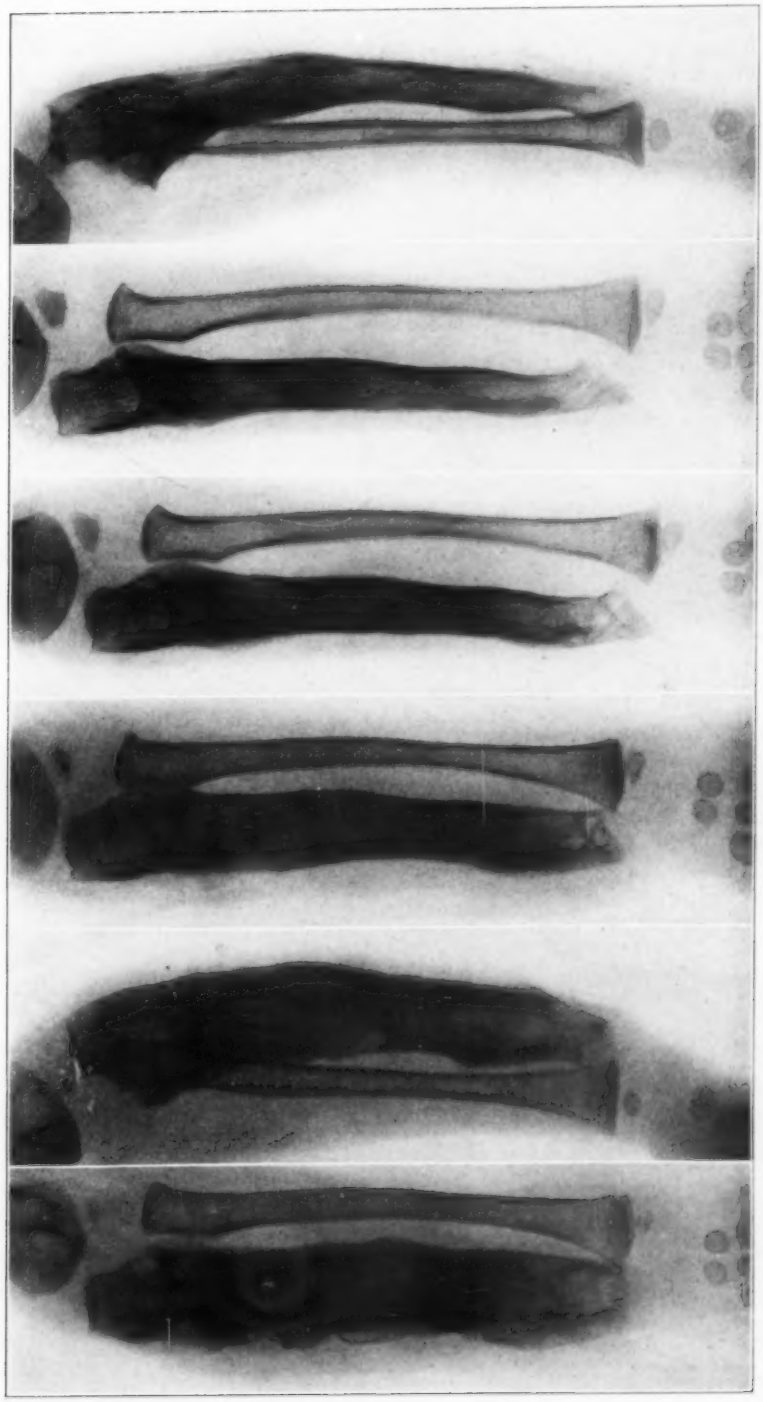

FIG. 13 FIG. 14 FIG. 15 FIG. 16 FIG. 17

August 8, 1935 September 9, 1935 November 6, 1935 January 7, 1936 March 17, 1936

A series of roentgenograms of Patient E. F., showing progressive stages in the healing of the right ulna. On March 17, 1936, this bone was quite dense, but there was evidence of a defect at the distal end.

FIG. 18

Patient E. F., September 9, 1935, showing alteration of the right femur in the region of the greater trochanter and below it. The disability cleared up entirely without local treatment.

surgical wound. The swelling of the forearm continued to extend, and an aspiration of the upper part of the forearm on May 4 yielded pus containing staphylococci; a subsequent aspiration on May 6 yielded pus containing streptococci and staphylococci. The forearm was incised for drainage of the soft tissues on May 7. The patient received staphylococcus bacteriophage intravenously beginning on April 24 and streptococcus serum beginning on May 7. The injections of these agents were continued to April 1936.

FIG. 19

Patient E. F., April 14, 1936. The surgical incisions are entirely healed and there is no disability.

FIG. 20

Patient E. F., April 14, 1936. Note the perfect extension and function of the hand. This patient has since continued in excellent condition.

Roentgenograms of the forearm were made from time to time. Figures 7 and 8 are roentgenograms taken on April 22, 1935, just preceding the first operation. There is only slight suggestion of change at the lower end of the ulna. Figure 9 shows the condition on April 27, five days after operation. The roentgenogram shown in Figure 10 was taken on May 7, 1935. Roentgenograms taken at approximate intervals of one month record the changes in the bone. Figure 11, showing the condition on June 7, 1935, suggests that complete destruction of the ulna was to be expected. However, Figures 12 and 13, roentgenograms of July 9 and August 8, indicate beginning limitation of the inflammatory process. On September 9 (Fig. 14), the ulna appears to be more clearly defined. On this date, because of a limp, a roentgenogram of the hips and pelvis (Fig. 18) was taken, disclosing a defect near the greater trochanter of the right femur. This lesion was neglected and has receded entirely. The roentgenogram of November 6 (Fig. 15) shows a more sharply defined ulna, and on January 7, 1936 (Fig. 16) there is evident still further progress of healing. On March 17 (Fig. 17), the ulna appears abnormally dense and, although somewhat enlarged, has assumed a reasonably normal contour. The lower end is, however, deformed and evidently there has been some injury to the epiphyseal cartilage in this location. Figures 19 and 20 show the healed forearm and the freedom of movement. At the present time this patient is quite free from any disability and uses this forearm by preference rather than the other. The lesion of the femur no longer gives any symptoms.

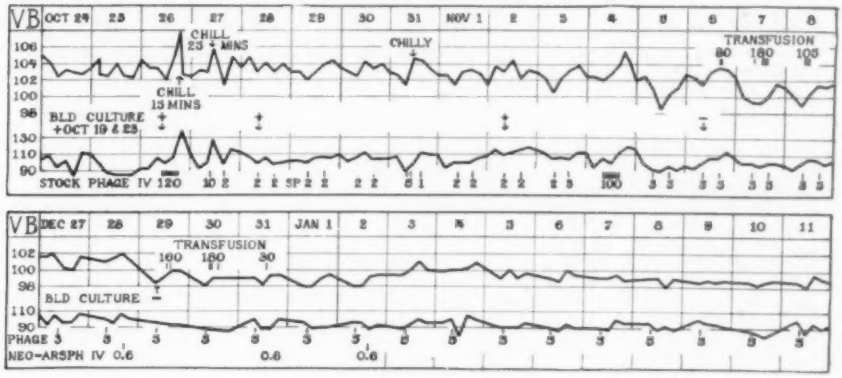
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FIG. 21

Abbreviated clinical record of Patient V. B., male, aged thirty-four, with discomfort in the right hip and blood culture positive for staphylococcus aureus on October 19, 21, 23, 26, 28, and November 2. This patient had clinical signs of double pneumonia and endocarditis. Roentgenograms of the hip joint were repeatedly negative. He received a series of bacteriophage doses on October 26, resulting in a chill and a rise of temperature to 107.8. Smaller doses of stock bacteriophage were continued to October 28. On October 29, specific bacteriophage was used,—two cubic centimeters given intravenously morning and evening. On October 31, following two doses—namely, two and three cubic centimeters given intravenously—the patient felt chilly and his temperature rose to 104.6. On November 4, a series of doses of bacteriophage to a total amount of 100 cubic centimeters was followed by a rise in temperature to 105.4 and by a fall the next day to 98.6. This appears to have been a bacteriophage reaction, and the blood culture taken on November 6 remained negative. Human blood was given in divided doses on November 6, 7, and 8. Subsequent blood cultures on November 9, 13, 24, December 10, and December 29 remained sterile. Sixth-tenths of a gram of neoarsphenamine in water was given intravenously on November 14, 19, 25, December 2, 5, 10, 12, 14, 16, 18, 20, 22, 24, 28, 30, and January 2. The condition of the heart and the lungs became quite satisfactory, but the discomfort in the right hip continued. On November 25, periosteal thickening was recognized along the inner border of the right ilium by palpation. The chart shows the temperature and pulse to December 11. Since that time the daily bacteriophage doses have been continued. The patient now appears to be convalescent.

FIG. 22

Roentgenogram of right iliac crest of Patient V. B. on November 28, 1936. Note alteration of internal border of iliac crest.

FIG. 23

Roentgenogram of right ilium of Patient V. B. on January 2, 1937. Note alteration near the crest of the ilium in the area of the gas bubble within the intestine.

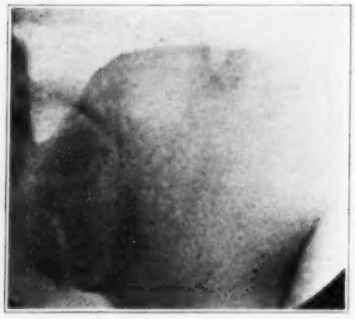

FIG. 24

Roentgenogram of right ilium of Patient V. B. on January 6, 1937. Alteration near the iliac crest is still evident.

Another patient now under observation in the hospital may serve as a further illustration of bacteriophage therapy in hematogenous osteomyelitis.

V. B., male, aged thirty-four, was admitted to the Hospital on October 16, 1936. He is a professional acrobat and a trapeze artist. His chief complaint on admission was pain in the right hip, which had been present for two days. This followed a cold which he had had for about a week. The pain was so severe that he had been confined to bed. Physical examination revealed a soft systolic murmur at the base of the heart and a slight limitation of motion of the right hip upon medial rotation of the thigh. The other movements of the hip joint were free. He presented a puzzling diagnostic problem, and for the first two weeks it was thought that a low-grade pneumonia was the essential condition present. However, inasmuch as his temperature remained high (104 to 106), blood cultures were taken on October 19, 21, and 23. All of these gave a positive growth of staphylococcus aureus developing rather slowly. Figure 21 shows part of his abbreviated clinical record from October 24 to November 8, inclusive, and again from December 27 to January 11, 1937, inclusive. On October 26, it was decided to give him intravenous bacteriophage treatment and he received 120 cubic centimeters of stock staphylococcus asparagin bacteriophage in divided doses beginning at 10:30 a.m. and ending at 6:30 p.m. About half an hour later the patient had a chill, which lasted for fifteen minutes, and at the end

of the chill his temperature reached 107.8. On the next day bacteriophage was continued—ten cubic centimeters at 9:40 a.m. and two cubic centimeters at 4:15 p.m. On October 28, the blood culture was again taken, and small doses of bacteriophage were given morning and evening. On October 29, specific bacteriophage, prepared from the patient's own blood culture, was substituted for the stock bacteriophage previously used, and this was given in small doses morning and evening on October 29 and 30. The blood culture, taken on October 28, now showed a positive growth, and it was decided to attempt to produce another shock by a series of bacteriophage doses. On October 31, the patient was given two cubic centimeters of specific bacteriophage at 8:50 a.m. and three cubic centimeters at 11 a.m. He then complained of feeling chilly, and no further doses were given until 4 p.m. The temperature rose to 104.6, but the reaction was not a satisfactory one. Blood culture, taken on November 2, was again positive, and, on November 4, another series of doses of bacteriophage were given in the attempt to produce a shock, the total amount of bacteriophage being 100 cubic centimeters. He did not develop a frank chill, but his temperature reached 105.4 and subsequently descended to 98.6 at noon on November 5. This behavior suggested a fairly satisfactory reaction to the bacteriophage, but its atypical character tended to support the tentative diagnosis of vegetative endocarditis. In fact, at this time the heart was enormously dilated and there was a quite distinct mitral murmur. Blood culture, taken November 6, remained negative. The patient was given small intravenous injections of citrated human blood on November 6, 7, and 8, and the doses of bacteriophage were continued morning and evening in amounts of five cubic centimeters. Subsequent to November 8, the patient had negative blood cultures taken on November 9, 13, 24, and December 10 and 29; these all remained negative. Because of the tentative diagnosis of endocarditis, six-tenths of a gram of neoarsphenamine was given intravenously on November 14, 19, 25, December 2, 5, 10, 12, 14, 16, 18, 20, 22, 24, 28, 30, and January 2. Bacteriophage treatment was continued during this time. The condition of the heart and lungs became much more satisfactory, but the patient became emaciated and extremely weak, being unable to turn himself in bed, and the care of the skin became a serious problem. The lower half of Figure 21 shows the chart from December 27. It is evident that the temperature had already assumed a lower level and after December 29 it no longer approached 102. Bacteriophage doses had now been reduced to one per day and, because of the development of numbness of the hands and feet, neoarsphenamine was discontinued after January 2. The patient has continued to convalesce slowly.

The condition of the right hip was subjected to roentgenographic study, but it was impossible to find any evidence of alteration in the femur or in the hip joint. About November 20, the patient complained of tenderness over the crest of the right ilium, and subsequently muscle contracture prevented the extension of the right thigh. By November 25, a firm tender mass, extending along the inner border of the right ilium, could be palpated, but there was no evidence of pointing at any spot. A tentative diagnosis of osteomyelitis of the ilium has been supported by roentgenograms taken on November 28, 1936, and January 2 and 6, 1937. (See Figures 22, 23, and 24.) Along with the evidence of osteomyelitis of the iliac crest there have been marked swelling of the right inguinal lymph nodes, a very marked oedema of the scrotum, and slight oedema of the right foot and ankle. This local condition in the ilium has greatly improved. The scrotal oedema and the oedema of the foot have entirely disappeared, and the swollen lymph nodes have diminished considerably in size. Tenderness along the iliac crest has entirely disappeared, but the periosteal thickening can still be recognized by palpation in this region. We are very hopeful that this patient will make a complete recovery without incision.

These cases may serve to illustrate what can be accomplished by conservative use of biological and chemotherapeutic agents to assist general resistance to infection of bone.

Figure 25 suggests the mode of transport of staphylococci in the

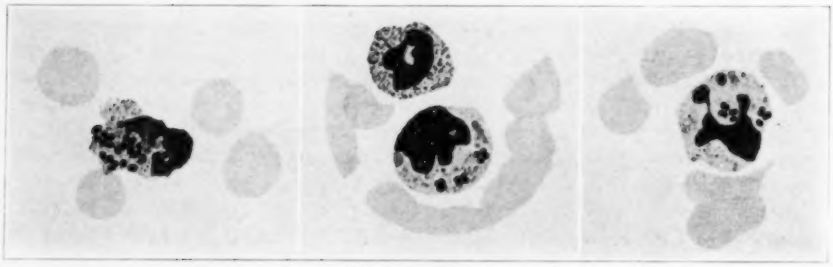

FIG. 25

Phagocytosed staphylococci in the circulating blood of Patient F. B. approximately twelve hours before death from severe staphylococcic sepsis. The blood culture taken at this time showed over 5,000 colonies of staphylococcus aureus per cubic centimeter of blood.

circulating blood. This picture represents leukocytes seen in a film of blood taken from the finger tip of a patient, F. B., with severe staphylococcic sepsis about twelve hours before his death. We have been unable to identify any staphylococci free in the blood plasma. It is, however, quite easy to find them within the polymorphonuclear leukocytes. A similar observation of phagocytosed bacteria in the circulating blood has been made by others, notably by Simon and by Pepper and Farley. In our patient the blood culture taken at the same time yielded approximately 5,000 colonies of staphylococcus aureus per cubic centimeter of blood. Here we have a visible demonstration of one mode of transport of bacteria in the circulating blood.

SUMMARY

1. The filterable agent of transmissible bacteriolysis causes solution of the respective bacteria in watery culture media. In the circulating blood of the living animal it apparently fails to cause such solution, but exerts an opsonic effect, favoring more effective phagocytosis.

2. When properly employed, such a lytic agent brings aid to the body defenses in overcoming infection with the staphylococcus, not only in furuncles, carbuncles, and septicaemia, but also in the bone lesions of staphylococcic osteomyelitis.

3. Staphylococci have been observed within polynuclear neutrophilic leukocytes of the circulating blood.

The author wishes to thank Dr. William H. Meyer, Professor of Roentgenology, for his cooperation, and also his various colleagues in the Department of Pathology and Bacteriology, who have carried the chief burden of this work.

REFERENCES

1. HANKIN, E. H.: On Sporadic Cases of Cholera. Indian Med. Gaz., XXXI, 282, 1896.

Les microbes des rivières de l'Inde. Ann. de l'Inst. Pasteur, X, 175, 1896.

L'action bactéricide des eaux de la Jumna et du Gange sur le microbe du choléra. Ann. de l'Inst. Pasteur, X, 511, 1896.

2. d'Herelle, F.: The Bacteriophage and Its Behavior. pp. xiv, 629. Baltimore, Williams & Wilkins, 1926.

The Bacteriophage and Its Clinical Applications. pp. vii, 254. Springfield, Illinois, Charles C. Thomas, 1930.

Bacteriophage as Treatment in Acute Medical and Surgical Infections. Bull. New York Acad. Med., VII, 329, 1931.

3. MacNeal, W. J.: Bacteriophages as a Help in the Treatment of Infections in Children. New York State J. Med., XXXI, 1383, 1931.
4. MacNeal, W. J.: Specific Treatment of Septic Infections, Particularly with Aid of Bacteriophages. Am. J. Med. Sciences, CLXXXVII, 623, 1934.
5. MacNeal, W. J., and Frisbee, F. C.: Bacteriophage as a Therapeutic Agent in Staphylococcus Bacteremia. J. Am. Med. Assn., XCIX, 1150 1932.
6. MacNeal, W. J., and Frisbee, F. C.: Bacteriophage Service to Patients with Staphylococcus Septicemia. Am. J. Med. Sciences, CXCI, 170, 1936.
7. MacNeal, W. J., and Frisbee, F. C.: One Hundred Patients with Staphylococcus Septicemia Receiving Bacteriophage Service. Am. J. Med. Sciences, CXCI, 179, 1936.
8. MacNeal, W. J., Frisbee, F. C., and Slavkin, A. E.: Mechanism of Bacteriophage Action in Staphylococcus Bacteremia. Proc. Soc. Exper. Biol. and Med., XXX, 12, 1932.
9. Moore, D. C., Blinn, A. B., and MacNeal, W. J.: Compound Fracture Complicated by Prolonged Streptococcus and Staphylococcus Septicemia, with Recovery. Am. J. Surg., XXIX, 143, 1935.
10. Pepper, O. H. P., and Farley, D. L.: Practical Hematological Diagnosis. pp. 152 and 441. Philadelphia, W. B. Saunders Co., 1933.
11. Simon, C. E.: A Manual of Clinical Diagnosis by Means of Microscopic and Chemical Methods, for Students, Hospital Physicians, and Practitioners. Ed. 10, p. 980. Philadelphia, Lea and Febiger, 1922.
12. Town, A. E., and Frisbee, F. C.: Bacteriophage in Ophthalmology; Preliminary Report. Arch. Ophthalmol., VIII, 685, 1932.
13. Twort, F. W.: An Investigation on the Nature of Ultra-Microscopic Viruses. Lancet, II, 1241, 1915.

MALUNION OF FRACTURES AND DEFORMITIES OF LONG BONES

An Improved Technique for Correction by Osteotomy

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When a complete transverse osteotomy of a long bone is performed by some of the customary methods, there is danger of displacement of the fragments, or, in some cases, of non-union at the site of osteotomy. Deformities of long bones occur chiefly as a result of fractures with malunion, of deficiency diseases such as rickets, of osteomyelitis, and of anterior poliomyelitis.

The problem has been to devise an operation which will correct the deformity and at the same time maintain continuity of the bone. Theoretically, a greenstick fracture at the site of the angulation, by making correction manually, would satisfy the requirements if such a procedure were practical. In former times this was done to correct genu valgum by forcibly making a manual epiphyseal fracture at the distal extremity of the femur by the procedure known as epiphyseolysis.[1] Fear of growth disturbances and other complications has caused this method to become obsolete.

The writer has worked out an osteotomy by which deformities can be corrected without loss of continuity of the bone. Briefly, the operation consists of the excision of a section of bone, resembling a truncated wedge, at the site of the angulation or deviation. The osteotomy extends two-thirds or four-fifths through the bone transversely, the distance depending on the density of the bone tissue. After this section has been excised, the mass of bone in the cross-section at the site of the operation is reduced in size, so that only moderate manual force is required to bend it and produce an incomplete or greenstick fracture. In the correction of the deformity this incomplete fracture is produced by closing the space from which the truncated wedge is removed.

A mechanical explanation of the procedure is as follows: The column of bone which maintains continuity after the excision of the truncated wedge has sides of almost equal length. The manual force used to correct the deformity is applied to this column. As the space is closed and correction is made, the bone column is partially crushed and impacted into itself, so that continuity is maintained.

The mechanics involved are changed considerably if a simple wedge osteotomy, extending part of the distance transversely through a bone, is performed, for, when an attempt is made to correct the deformity manually, a fulcrum is established at the angle of the wedge-shaped space.

Excision of the simple wedge also results in the necessity for a much greater force to correct the deformity manually, and, therefore, such an osteotomy must extend a greater distance transversely through the bone. Forcible correction will produce a complete fracture and loss of continuity of the fragments, with danger of displacement.

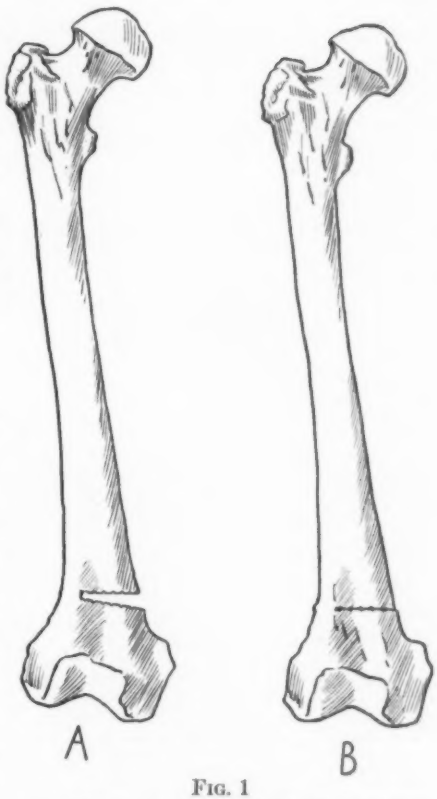

FIG. 1

A: Diagram of femur, illustrating deformity in a case of medial angulation of the knee, with truncated wedge of bone excised.

B: Correction by incomplete fracture of bone column, which maintains continuity, with closure of space.

TECHNIQUE OF OPERATION

To estimate the size of the truncated wedge of bone to be excised, a long roentgenogram, centered on the point or angle of deviation, should be made. For example, in a case of genu valgum, a film, seven by seventeen inches, may be used. With the roentgenogram on a viewing box, a tracing of the bone outline is made on thin paper. The outline tracing of the bone is cut out with scissors. By cutting the paper figure at the point of deviation and straightening it, the size of the section of bone to be excised can be determined. In making this estimation, one must take cognizance of the fact that in roentgenograms there is some magnification of bones, depending on the thickness of the bone and the underlying soft parts.

In performing the operation, the bone at the site of the deformity is exposed. The periosteum is incised longitudinally and retracted on the outer side of the angle of deviation by retractors which separate the soft parts from the bone. The outline of the truncated wedge of bone to be excised is marked on the bone surface. A sharp punch is used to mark for drill holes every six millimeters along this outline. Small holes are drilled through the bone at these punch marks, the soft parts on the deep side of the bone being protected by retractors. The osteotomy is performed with a very thin, sharp chisel or osteotome. The drill holes prevent splintering of the bone. After the truncated wedge of bone has been removed, the space is closed manually by an incomplete or greenstick fracture of the bone, which maintains continuity. In this way, the deformity is corrected without danger of separation of the fragments, and

healing of the bone is assured by the maintenance of a unified structure. Following the operation, immobilization of the part is maintained by a plaster cast which may be wedged if there is tendency toward recurrence of the deformity on account of tension by the soft parts. In cases where there are contractures and extreme shortening of the soft parts, it is necessary to lengthen them by tendoplasties, myotomies, or fasciotomies, as preliminary procedures before the osteotomy.

COMMENT

In malunion of fractures with angulation deformities, internal fixation is not necessary after osteotomy, except in malunited fractures of the forearm bones. Here, the tension of

FIG. 2

Case 5. Lateral view of left femur, showing fragmentation, displaced spicules of cortex, and malunion with anterior angulation deformity.

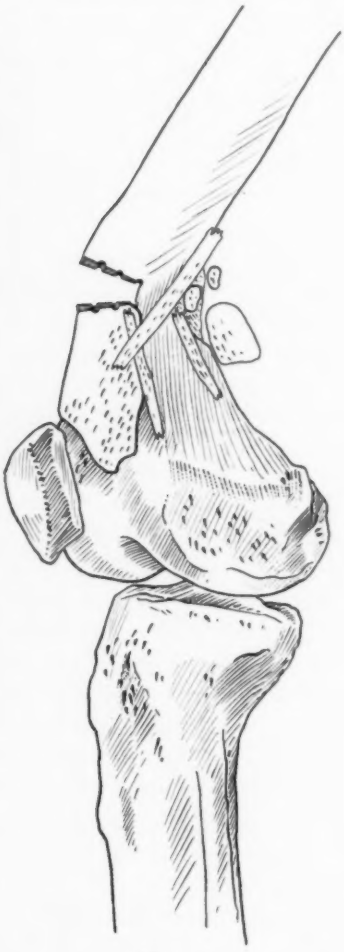

FIG. 3

Case 5. Diagram of lateral view, illustrating truncated-wedge osteotomy. Attention is called to narrowing of space medially for correction of lateral bowing.

the shortened muscles and soft structures will cause the deformity to recur partially after any osteotomy unless internal fixation is used, and the wedging of a cast in forearm deformities is usually impractical. However, the truncated-wedge osteotomy leads to quicker healing on account of the partial union which remains after operation.

In malunion of transverse fractures without overlapping, the excised truncated wedge consists chiefly of bone callus which has filled in the space between the fragments. It is obvious in these cases that no shortening is caused by the osteotomy. In deformities which result from other causes, the question of a small amount of shortening must be considered. However, the assurance of continuity of the bone with a minimum of shortening will usually outweigh this objection. In bilateral cases, as in genu valgum, the element of shortening is of no great importance.

In working out the details of this operation, it was considered originally that correction of deformities by this method could be made in one plane only. However, in Case 5, by making the truncated wedge thinner at its medial end, it was possible to correct both anterior angulation and lateral bowing of the femur.

FIG. 4

Case 5. Lateral roentgenogram of femur, three months after operation, showing satisfactory alignment of the anterior cortex. The appearance of loss of bone structure in the posterior cortex is due to fragmentation and splintering in the original fracture.

In malunited fractures with overlapping of the fragments, it is obvious that the problem is different and the rationale of treatment is changed, so that this operation does not apply.

The writer has performed this operation three times for post-poliomyelitis medial angulation deformity of the knee in which the deformity was chiefly in the femur.

In another such case, the osteotomy was performed on the tibia because the deviation was located in this bone. By this procedure also, correction of the deformity was made in malunion of an old fracture of the radius and in malunion of a comminuted fracture of the femur.

CONCLUSIONS

1. The axis of a long bone can be deviated by using manual force to make a greenstick or incomplete fracture when a cross-section of the bone is reduced in size by the excision of a truncated wedge of bone.

2. An osteotomy by excision of a truncated wedge transversely from a long bone at the site of a deviation deformity will permit correction manually by an incomplete fracture of the bone.

3. In malunited fractures with angulation deformities, this osteotomy prevents separation of the fragments and danger of non-union after correction.

4. Healing after a truncated-wedge osteotomy requires immobilization in a plaster cast for a minimum length of time, because there is not a complete loss of continuity and the circulation in the bone is disturbed less than after a complete osteotomy.

REFERENCE

1. Jones, Sir Robert, and Lovett, R. W.: Orthopedic Surgery. Ed. 2, p. 327. New York, Wm. Wood & Co., 1929.

A PROCEDURE FOR STIMULATION OF LONGITUDINAL GROWTH OF BONE

An Experimental Study *

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Inequality in length of the bones of the extremities may result from one or more of a wide variety of causes which operate during the active growing period of the epiphyses. Either lengthening or shortening may result from the same etiological factors. The former follows irritative or stimulative lesions, and the latter follows destructive affections of the epiphyseal cartilage. In both the clinical and experimental fields, numerous observations have been made on this interesting subject.

CLINICAL OBSERVATIONS

Trauma: Injury of the epiphyseal cartilage plate may retard or actually arrest the growth of bone.[31, 32, 33] A classic example of arrested growth is seen in Madelung's deformity of the wrist, which follows after injury of the distal epiphysis of the radius. On the other hand, in overriding fractures of the shafts of long bones in children, the resultant shortening is usually equalized by a subsequent compensatory increase in length, and occasionally the affected bone actually becomes longer than the normal one.[7, 9, 36] This compensatory reaction probably results from some disturbance of the blood supply of the shaft, which, in turn, exerts a stimulative effect upon the growing ends.

Infection: In children various forms of infection cause disturbance of the growth of long bones. When the epiphyseal cartilage is destroyed by osteomyelitis, shortening results, but when the lesion is near the growing center, without actually involving it, lengthening often follows.[34, 35, 39] Shortening of the limb, as a result of tuberculous or pyogenic infection of a joint, is a very familiar observation; however, lengthening of the limb also may occur. Wagstaffe[37] reported twenty-five cases of chronic diseases of the knee joint in children. Growth disturbances occurred in 76 per cent. of the cases, with lengthening of the bones in most instances. The saber-shaped tibia of bone syphilis is sometimes definitely elongated, particularly when the infection is congenital.[15, 40] Also, infection of the soft tissue in the vicinity of the epiphysis may cause lengthening of the bone.[29]

Tumors: Of the various tumors of bone, chondroma is the one which commonly affects the growth and nearly always causes shortening.[38]

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Occasionally, in children, lengthening of the bones may be associated with soft-tissue neoplasms such as hemangiomata and multiple neurofibromata.

Vascular Disturbances: Lengthening of the bones has been reported as a result of several conditions which cause either active or passive hyperaemia. Horton[21] reported congenital aneurysm of the extremities in twenty-three cases, with lengthening of the bones in eighteen instances. Occasionally thrombophlebitis of long standing is followed by increased growth in the length of bones. Lengthening of the limb of the operated side has been observed after lumbar sympathectomy in cases of Hirschsprung's disease, spastic paralysis, and infantile paralysis.[16, 17]

Infantile Paralysis: Shortening of an extremity is commonly observed in infantile paralysis and is probably the result of atrophy of the muscles, with resultant lack of stimulation of the growth centers. Possibly altered circulation is also a causative factor.

Congenital Anomalies: Congenital hypertrophy may involve one entire side of the body, or one limb, or a single bone of the limb.[5, 26] Absence or underdevelopment of a bone or of an epiphysis occasionally is accountable for shortening of an extremity.[12, 25]

EXPERIMENTAL OBSERVATIONS

The fact that longitudinal growth of bones takes place only at their ends was first demonstrated by Hales[14] in 1727. This worker drilled two holes, one-half an inch apart, in the shaft of the tibia of a growing chicken. Observations made two months later showed that the two holes remained the same distance apart, although the entire bone had increased one inch in length. Similar experiments with modifications and improvements in technique were performed later by Duhamel[10], Hunter[23], Ollier[28], Hass[20], Gatewood and Mullen[13], and Bisgard[4]. In other experiments Ollier excised the epiphyseal cartilages of the long bones of young dogs, with resultant cessation of growth. Also, Bidder[2] inserted needles into the epiphyseal plates, following which the injured ends of the bone showed a decreased rate of growth. Similar but more detailed experiments were performed by Hass.[19] Basing his work upon these fundamental findings, Phemister[31] devised a new operation for fusion of the epiphyseal cartilage on one or on both sides of the bone.

Many workers have attempted by various means experimentally to stimulate epiphyseal growth and have hoped thereby to arrive at some method which might be used clinically to equalize the length of the extremities. In 1910, Meisenbach[27] reported the results of such experiments made on young rabbits. Various foreign materials—such as sterile water, fine sterile graphite pegs, staphylococcus vaccine, tincture of iodine, carbolic acid, alcohol, and formalin—were injected into the vicinity of the proximal epiphyseal cartilage of the tibiae. In each case, roentgenographic and microscopic examinations were made from three to six weeks after the injection. In most instances, no appreciable change was produced. In the cases in which formalin was injected, there was some de-

gree of widening of the bone, due to thickening of the cortex, but the total length was decreased. Harbin[15], basing his work on the clinical observation of overgrowth in cases of osteomyelitis, injected a suspension of staphylococcus aureus into the region of the distal epiphyseal cartilage plate of the femur of a puppy. His results showed noticeable shortening of the limb. Similar experiments were made upon guinea pigs by Bohlman[6], in 1929, who used foreign materials—such as iron, copper, lead, wood, bone, ivory, camphor, thymol, and asphalt—in the form of small pegs or powders. The materials were inserted through drill holes directly into, immediately proximal to, or distal to the distal epiphyseal cartilage plate of the femur. Observations made at the end of three months failed to show lengthening in any of the cases; on the contrary, marked shortening often resulted.

There are three chief sources of blood supply to each bone: (1) the nutrient artery, (2) the periosteal blood supply, and (3) the epiphyseal blood supply.[18, 24, 39] Disturbance of one or more of these sources of supply is undoubtedly a factor which alters the rate of growth of the epiphyses. Certain of the experimental studies along this line are of decided significance. Ollier[28] ligated the nutrient artery of a growing bone and found no apparent change in growth. Hass[18] produced various vascular changes in the bones of the feet of young dogs. Ligation of all of the large vessels of the dorsum of the foot, as well as direct destruction of the nutrient arteries to the metatarsal bones, did not affect the longitudinal growth. However, remarkable shortening resulted when he cut off the blood supply to the epiphyseal region by stripping the soft tissue from the distal end of the bone. He concluded that the maintenance of the normal longitudinal growth of bone is dependent upon a sufficient blood supply to the epiphyseal region. Pearse and Morton[29, 30] observed that venous stasis, produced by ligation of the large veins of the hind limbs of dogs, hastened the repair of artificially produced fractures of the fibula. Ligation of the main arteries, however, produced no effect because of the rapid formation of collateral circulation. It has been shown both in animals and in clinical experiments that lumbar sympathectomy produces a prolonged arterial hyperaemia of the lower limb on the operated side. Harris and McDonald[16, 17] reported their results after this operation in cases of limbs shortened by infantile paralysis. In twenty of their twenty-nine cases in which the sympathetic effect was maintained, the growth of the extremity was increased. However, Cannon[8], Bacq[1], Bisgard[3], and others did not find any change in the longitudinal growth of the limbs of unilaterally sympathectomized animals.

In 1933, Ferguson[11] described a procedure for stimulation of the longitudinal growth of bone. He curetted the marrow through small drill holes which were made midway between the middle of the shaft and the epiphyseal line. Observations upon seven bones operated on in four cases showed a gain in length of from one-eighth to one-sixth of an inch after from three to five months.

TABLE I

MEASUREMENTS OF LONGITUDINAL GROWTH OF TIBIAE AFTER INSERTION OF FOREIGN MATERIAL INTO DRILL HOLE IN BONE IMMEDIATELY DISTAL TO THE PROXIMAL EPIPHYSEAL CARTILAGE PLATE

Materials Inserted	Rabbit No.	Length of Tibiae Before Operation		Time from Operation to Autopsy (*Months*)	Length of Tibiae at Autopsy		Length of Operated Tibiae Compared with Control Tibiae	
		Left (*Millimeters*)	Right (*Millimeters*)		Left—Control (*Millimeters*)	Right—Operated (*Millimeters*)	Shortening (*Millimeters*)	Lengthening (*Millimeters*)
None	1	67.5	67.5	3	88.5	88.5		
	2	73.0	73.5	3	95.5	96.0		
Cotton	3	50.5	51.0	1	69.0	69.0	0.5	
Gauze	4	65.5	66.0	3	92.0	92.0	0.5	
	5	69.0	68.0	3	94.0	93.5		0.5
	6	70.0	70.0	3	93.5	93.5		
Paper	7	57.0	57.5	3	96.0	96.0	0.5	
Wood	8	72.5	73.0	3	91.0	91.0	0.5	
	9	72.0	72.0	3	94.0	94.5		0.5
Iron Shot	10	74.0	74.5	3	95.0	94.5	1.0	
	11	81.0	81.0	1.5	91.0	91.0		
	12	68.5	68.5	1.5	82.5	82.5		

The influences of active function of the muscles (stress and strain) upon the growth of bone was well shown by Howell[22], who severed the right brachial plexus of young dogs and observed the subsequent growth. The bones on the operated side were found noticeably shorter and considerably thinner than those on the control side.

In the experiments reported in this article, we have repeated, with minor modifications, the work of Meisenbach, Pearse, Ferguson, and others (Groups I, II, and III); also, we have used other procedures which are for the most part original (Group IV). The results of our experiments have been sufficiently encouraging to warrant a report.

METHOD OF EXPERIMENT

The experiments were performed upon fifty-two young rabbits, aged from five to eight weeks and weighing from 600 to 800 grams. In each case, the right tibia or the right femur and tibia were operated upon, and the corresponding bones of the left side were employed for control purposes. Ether anaesthesia was used. The right leg was shaved and the skin was prepared with iodine and alcohol. After operation, the wound was closed in layers with silk sutures and sealed with collodion. (The wounds healed *per primum* in all animals within a period of ten days.) Roentgenograms of both legs, at a uniform target distance of sixty-five centimeters, were taken immediately before operation and at monthly intervals following operation until the time of autopsy. Autopsies were performed at periods varying from two weeks to six months after operation. Longitudinal measurements of the bones were taken from the roentgenograms and also from the autopsy specimens. Tables I, II, III, and IV show the measurements of the bones of the legs operated upon, also those of the untouched legs. The experiments were divided into four groups as follows:

I. Insertion of Foreign Material into a Drill Hole Placed Immediately Distal to the Proximal Epiphyseal Cartilage of the Tibia

An incision, about one centimeter in length, was made on the anteromedial aspect of the upper end of the right tibia. Next, a small incision was made through the periosteum, from two to three millimeters distal to the epiphyseal line. Through this incision a small hole was drilled, tilting proximally, so that the inner end of the drill just reached the epiphyseal cartilage plate without boring into it. In two rabbits (Nos. 1 and 2), in order to estimate the effect of drilling alone, the wound was closed without any further procedure. In each of the remaining ten rabbits (Nos. 3 to 12 inclusive), a small piece of foreign material was introduced into the depths of the drill hole, following which the periosteum and soft tissues were closed in the usual manner.

As shown in Table I, various foreign materials—cotton, gauze, paper, wood, and iron shot—were used. Considering a difference in length of five-tenths of a millimeter to be within the range of normal variation, the

results showed no appreciable difference in length of the bone operated upon. These findings differ from those of Meisenbach[27] and Bohlman[6], who observed shortening after a similar procedure.

II. Indirect Interference of Circulation of Bone

In this series of experiments, performed upon twelve rabbits (Nos. 13 to 24 inclusive), various circulatory disturbances of the right posterior extremity were produced by the following methods: (1) ligation of the femoral artery; (2) ligation of the femoral vein; (3) stripping of the overlying soft tissues and application of a double, heavy silk ligature around the upper epiphyseal cartilage plate; and (4) stripping of all the soft tissues from the periosteum along the entire length of the shaft of the tibia, not including the epiphyseal ends. This last procedure interrupted the nutrient artery and also all other vessels connecting the covering of the bone with the surrounding tissues.

As shown in Table II, there was no appreciable change in the longitudinal growth after any of these experiments. The alteration of the blood supply which followed ligation of the femoral artery or vein was very transient, therefore the growth of the bone was not affected to any significant extent. The silk ligatures which were applied around the epiphyseal cartilage plate were found later, at autopsy, embedded in the periosteum of the metaphysis a short distance from the epiphyseal plate. The finding that destruction of the nutrient artery and the extraperiosteal blood supply caused no change in the longitudinal growth of bone agrees with the observations of Ollier[28] and Hass[18].

III. Ferguson's Operation—Curettage of Bone Marrow.

Ferguson's method[11] of stimulating the longitudinal growth of bone was performed on six rabbits. The bone marrow of the right tibia was curetted through a drill hole made midway between the middle of the shaft and the epiphyseal line. In four of the six rabbits (Nos. 25, 26, 27, 28), the marrow was curetted only through a drill hole made in the upper portion of the tibia, while in the other two rabbits (Nos. 29, 30), the marrow was also curetted through a second hole in the lower portion of the shaft of the bone. As listed in Table III, our observations at the end of from three to six months failed to show significant changes in the length of the operated bones. These findings differ from those noted by Ferguson in his clinical experiments upon patients.

IV. Stripping of the Periosteum

Twenty-two rabbits were used in this series of experiments. The right tibia alone was operated upon in eighteen animals (Nos. 31 to 48 inclusive), and both the right femur and tibia were operated upon in four animals (Nos. 49 to 52 inclusive). The periosteum of the tibia was exposed through a longitudinal incision on the anteromedial aspect of the bone, and that of the femur was exposed through a lateral incision. The

TABLE II

MEASUREMENTS OF TIBIAE AFTER INDIRECT INTERFERENCE WITH CIRCULATION OF BONE

Type of Operation	Rabbit No.	Length of Tibiae Before Operation		Time from Operation to Autopsy	Length of Tibiae at Autopsy		Length of Operated Tibiae as Compared with Control Tibiae	
		Left (*Millimeters*)	Right (*Millimeters*)		Left—Control (*Millimeters*)	Right—Operated (*Millimeters*)	Shortening (*Millimeters*)	Lengthening (*Millimeters*)
Ligation of right femoral artery	13	70.5	71.0	6 months	92.0	91.5	0.1	
	14	61.0	61.0	28 days	73.5	73.0	0.5	
	15	67.5	67.5	24 days	75.5	75.5		
Ligation of right femoral vein	16	70.0	69.0	6 months	101.5	101.5		1.0
	17	68.0	67.5	6 months	99.0	99.0		0.5
	18	70.0	70.5	6 months	94.0	94.0	0.5	
	19	58.5	58.0	21 days	64.0	64.0		0.5
Silk ligature around upper epiphyseal plate of tibia	20	73.0	73.5	3 months	83.5	84.0		
	21	85.0	85.0	3 months	89.0	89.0		
Stripping of muscles of right leg extra-periosteally	22	71.0	71.0	3 months	100.0	100.0		
	23	83.0	83.5	3 months	96.0	96.0	0.5	
	24	59.5	59.5	3 months	97.0	97.0		

TABLE III

MEASUREMENTS OF TIBIAE AFTER FERGUSON'S OPERATION (CURETTAGE OF BONE MARROW)

Type of Operation	Rabbit No.	Length of Tibiae Before Operation		Time from Operation to Autopsy (*Months*)	Length of Tibiae at Autopsy		Length of Operated Tibiae as Compared with Control Tibiae	
		Left (*Millimeters*)	Right (*Millimeters*)		Left—Control (*Millimeters*)	Right—Operated (*Millimeters*)	Shortening (*Millimeters*)	Lengthening (*Millimeters*)
Curettage of bone marrow	25	71.5	71.5	3	93.5	94.0		0.5
	26	76.5	76.0	3	90.0	90.0		0.5
	27	65.0	64.5	6	95.0	95.0		0.5
	28	69.5	69.5	6	97.5	97.5		
	29	68.5	68.5	3	94.0	94.5		0.5
	30	67.0	67.0	6	95.0	95.5		0.5

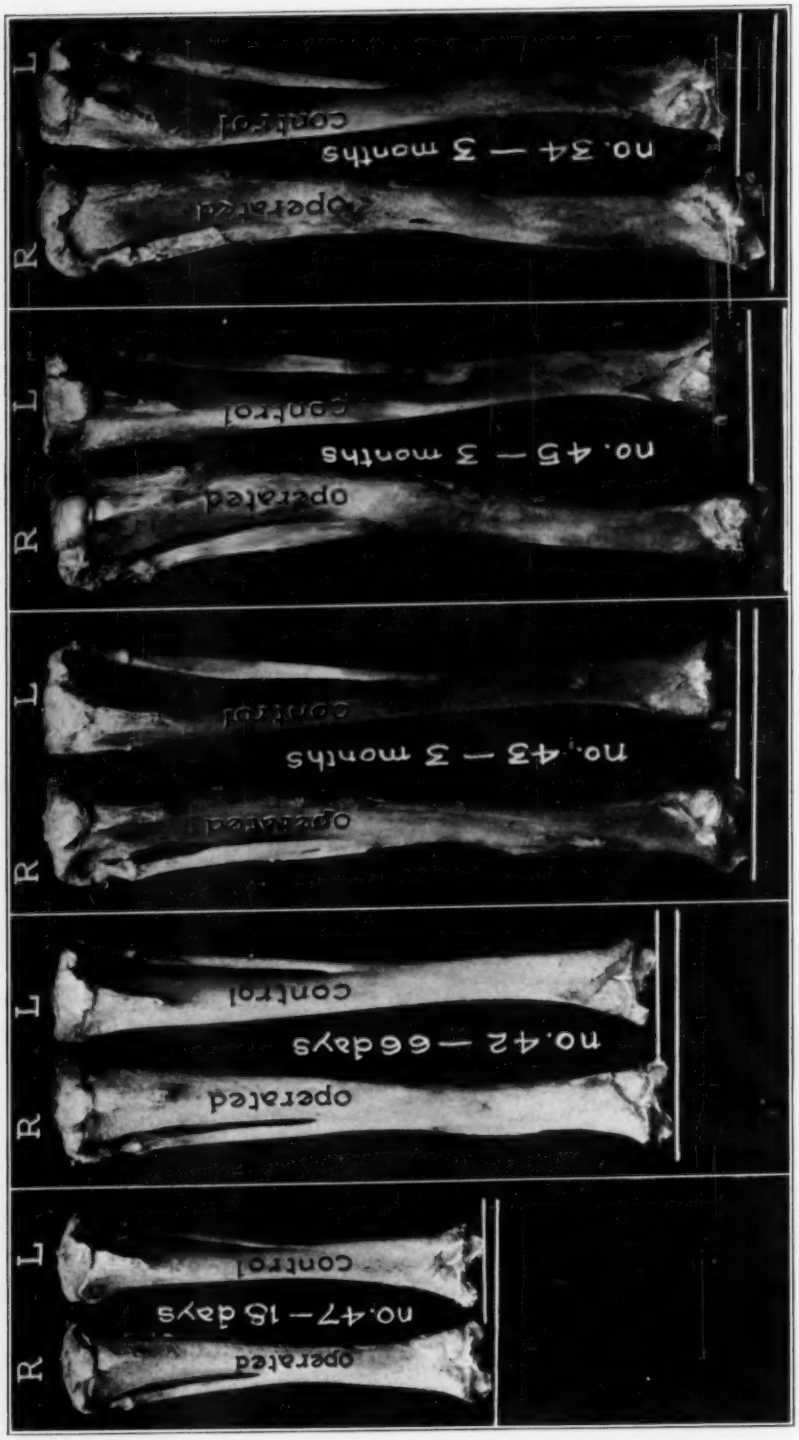

FIG. 1

Autopsy specimens following stripping of all or various portions of the shaft of the right tibia. (See Table IV.) Note the actual amount of longitudinal overgrowth of the right (operated) tibiae.

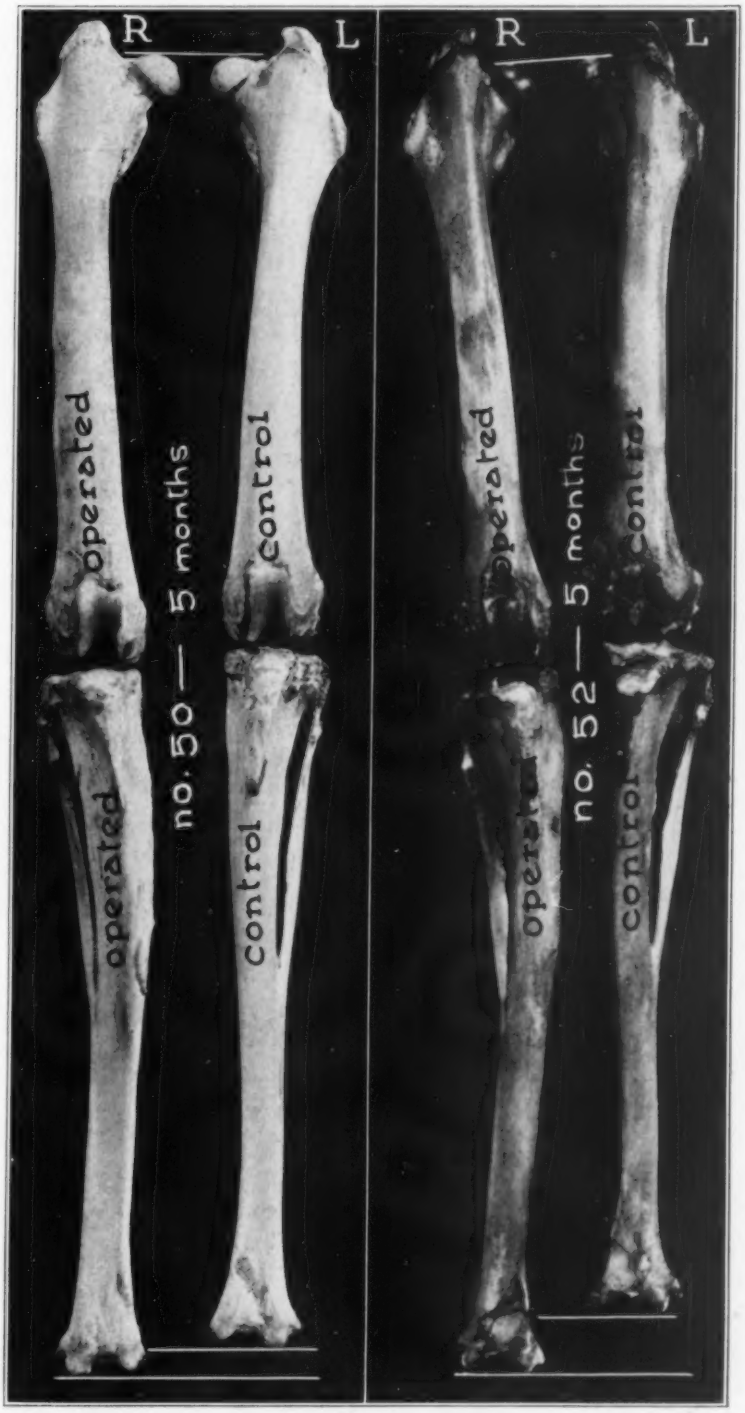

FIG. 2

Autopsy specimens of bones following stripping of periosteum of the lower half of the shaft of the right femur and upper half of the shaft of the right tibia. Note the longitudinal overgrowth of the bones on the right (operated) side.

TABLE IV

MEASUREMENTS OF BONES AFTER STRIPPING OF THE PERIOSTEUM FROM THE SHAFT OF THE RIGHT TIBIA AND THE RIGHT FEMUR

Type of Operation	Rabbit No.	Bone Operated Upon	Length of Bone Before Operation		Time from Operation to Autopsy	Length of Bone at Autopsy		Length of Operated Bone as Compared with Control Bone	
			Left (*Millimeters*)	Right (*Millimeters*)		Left—Control (*Millimeters*)	Right—Operated (*Millimeters*)	Shortening (*Millimeters*)	Lengthening (*Millimeters*)
Stripping of entire shaft of tibia	31	Tibia	59.0	58.5	20 days	63.5	66.0		3.0
	32	Tibia	66.0	65.0	23 days	73.0	74.5		2.5
	33	Tibia	74.5	74.5	1 month	87.0	90.5		3.5
	34	Tibia	67.0	67.0	3 months	95.5	100.0		4.5
	35	Tibia	61.5	61.0	3 months	96.0	98.0		2.5
	36	Tibia	57.5	57.5	5 months	95.5	96.0		0.5
	37	Tibia	56.0	56.0	5 months	92.0	93.5		1.5
	38	Tibia	54.0	53.5	5 months	92.0	95.5		4.0
	39	Tibia	52.5	52.0	5 months	92.0	96.0		4.5
	40	Tibia	53.0	53.0	5 months	93.5	97.0		3.5
Stripping of lower half of shaft of tibia	41	Tibia	68.5	69.0	21 days	73.0	75.5		2.0
	42	Tibia	60.5	60.0	66 days	82.0	85.5		4.0
	43	Tibia	64.0	64.0	3 months	93.5	96.0		2.5
Stripping of upper half of shaft of tibia	44	Tibia	63.0	63.0	3 months	92.0	95.0		3.0
	45	Tibia	63.0	62.0	3 months	95.0	100.0		6.0
Stripping of only the anterior surface of tibia	46	Tibia	58.0	57.0	19 days	62.0	63.0		2.0
	47	Tibia	58.0	58.0	18 days	57.5	59.0		1.5
	48	Tibia	63.0	63.0	15 days	65.0	65.0		
Stripping of periosteum of lower half of shaft of femur and upper half of tibia	49	Femur	41.5	42.0	5 months	82.5	84.5		1.5
		Tibia	49.5	50.0		93.0	95.0		1.5
	50	Femur	44.0	44.0	5 months	82.5	85.0		2.5
		Tibia	55.5	55.5		95.5	98.0		2.5
	51	Femur	49.0	50.0	5 months	81.5	83.0		0.5
		Tibia	59.0	59.0		93.0	93.0		
	52	Femur	54.5	55.0	5 months	82.5	85.5		2.5
		Tibia	60.0	60.0		92.0	97.0		5.0

periosteum was incised along the long axis of the bone and was stripped from all or various portions of the shaft of the bone with a curved blunt elevator. Care was taken not to injure the epiphyseal cartilage or the large blood vessels in the vicinity. Profuse bleeding was not encountered in any instance. The periosteum was replaced and sutured together with fine silk sutures after the desired amount of stripping had been accomplished. The wound was closed in the usual manner. As shown in Table IV, the animals were further divided into five groups, according to the extent of the stripping of the periosteum: (1) stripping of the periosteum from the entire circumference of the whole shaft of the tibia; (2) stripping of the periosteum from the entire circumference of the lower half of the shaft of the tibia; (3) stripping of the periosteum from the entire circumference of the upper half of the tibia; (4) stripping of the periosteum from only the anterior surface of the shaft of the tibia, leaving the nutrient artery intact; and (5) stripping of the periosteum from the entire circumference of the lower half of the shaft of the femur and the upper half of the tibia.

Table IV shows the measurements of the length of the bones after the preceding experiments. Figures 1 and 2 illustrate examples of the results obtained. Definite longitudinal overgrowth of the operated bone was observed in all instances except in the tibiae of rabbits Nos. 36, 48, and 51. The bones operated upon were seen to be slightly thicker and rougher than those of the control side, but, in spite of this, the periosteum was not particularly adherent.

The operation was repeated in rabbit No. 38 at the end of one month after the first operation, in rabbits Nos. 39 and 40 at the end of two months, and in rabbits Nos. 51 and 52 at the end of three months. Contrary to our expectations, there was no additional stimulation of the length growth which might be attributed to the second or repeated stripping procedure.

SUMMARY

In these experiments various surgical procedures were employed, with the hope of finding a method for stimulation of the longitudinal growth of bone. The first three groups of experiments (a repetition with minor modifications of the procedures of Meisenbach, Pearse, Ferguson, and others) failed to produce significant increase in the length growth.

By chance, in several animals, we observed that stimulation of the length growth was produced by the simple procedure of loosening or stripping the periosteum from the shaft of the bone. Consequently, this operation was repeated on twenty-two animals, with quite uniform and significant results, as shown in Table IV. With but three exceptions out of twenty-two rabbits, the operated leg showed definite lengthening when compared with the normal leg on the opposite side. Although the amount appeared to be small, it actually represented an increase of from 5 to 15 per cent. over the normal growth of the bone during that period of

time. Observations of the monthly roentgenograms showed that the most active stimulation of length growth of the bones took place during the first three months following the operation.

We are unable to give a definite explanation of the factors which, after the periosteum had been stripped, produced this stimulation of the longitudinal growth.

REFERENCES

1. Bacq, Z. M.: The Action of Abdominal Sympathectomy on the Growth of the Albino Rat and the Weight of the Genital Organs. Am. J. Physiol., XCV, 601, 1930.
2. Bidder, Alfred: Experimente über die künstliche Hemmung des Längenwachsthums von Röhrenknochen durch Reizung und Zerstörung des Epiphysenknorpels. Arch. f. Exper. Path. u. Pharmakol., I, 248, 1873.
3. Bisgard, J. D.: Longitudinal Bone Growth. The Influence of Sympathetic Deinnervation. Ann. Surg., XCVII, 374, 1933.
4. Bisgard, J. D., and Bisgard, M. E.: Longitudinal Growth of Long Bones. Arch. Surg., XXXI, 568, 1935.
5. Black-Milne, J.: Two Cases of Anomalies of Growth. British J. Child. Dis., XVII, 79, 1920.
6. Bohlman, H. R.: Experiments with Foreign Materials in the Region of the Epiphyseal Cartilage Plate of Growing Bones to Increase Their Longitudinal Growth. J. Bone and Joint Surg., XI, 365, Apr. 1929.
7. Burdick, C. G., and Siris, I. E.: Fractures of the Femur in Children. Ann. Surg., LXXVII, 736, 1923.
8. Cannon, W. B., Newton, H. F., Bright, E. M., Menkin, V., and Moore, R. M.: Some Aspects of the Physiology of Animals Surviving Complete Exclusion of Sympathetic Nerve Impulses. Am. J. Physiol., LXXXIX, 84, 1929.
9. David, V. C.: Shortening and Compensatory Overgrowth Following Fractures of the Femur in Children. Arch. Surg., IX, 438, 1924.
10. Duhamel, H. L.: Cinquième mémoire sur les os. Mémoires de l'Académie Royale des Sciences, p. 111, 1743.
11. Ferguson, A. B.: Surgical Stimulation of Bone Growth by a New Procedure. Preliminary Report. J. Am. Med. Assn., C, 26, 1933.
12. Freund, Ernst: Congenital Defects of Femur, Fibula and Tibia. Arch. Surg., XXXIII, 349, 1936.
13. Gatewood, and Mullen, B. P.: Experimental Observations on the Growth of Long Bones. Arch. Surg., XV, 215, 1927.
14. Hales, Stephen: Statistical Essays, Vol. I. London, 1727.
15. Harbin, Maxwell: Overgrowth of the Long Bones of the Lower Extremity. Report of Three Cases. Arch. Surg., XIV, 142, 1927.
16. Harris, R. I.: The Effect of Lumbar Sympathectomy on the Growth of Legs Shortened from Anterior Poliomyelitis. A Preliminary Report. J. Bone and Joint Surg., XII, 859, Oct. 1930.
17. Harris, R. I., and McDonald, J. L.: The Effect of Lumbar Sympathectomy upon the Growth of Legs Paralyzed by Anterior Poliomyelitis. J. Bone and Joint Surg., XVIII, 35, Jan. 1936.
18. Hass, S. L.: The Relation of the Blood Supply to the Longitudinal Growth of Bone. Am. J. Orthop. Surg., XV, 157, Mar. 1917; 305, Apr. 1917.
19. Hass, S. L.: The Changes Produced in the Growing Bone after Injury to the Epiphyseal Cartilage Plate. J. Orthop. Surg., I, 67, Feb. 1919.
20. Hass, S. L.: Interstitial Growth in Growing Long Bones. Arch. Surg., XII, 887, 1926.

21. Horton, B. T.: Hemihypertrophy of Extremities Associated with Congenital Arteriovenous Fistula. J. Am. Med. Assn., XCVIII, 373, 1932.
22. Howell, J. A.: An Experimental Study of the Effect of Stress and Strain on Bone Development. Anat. Record, XIII, 233, 1917.
23. Hunter, John: Experiments and Observations on the Growth of Bones, From the Papers of the Late Mr. Hunter. *In* The Works of John Hunter, With Notes. Edited by James F. Palmer. Vol. IV, p. 315. London, 1837.
24. Johnson, R. W., Jr.: A Physiological Study of the Blood Supply of the Diaphysis. J. Bone and Joint Surg., IX, 153, Jan. 1927.
25. Jones, Sir Robert, and Lovett, R. W.: Orthopedic Surgery, Chap. 25. New York, William Wood & Co., 1923.
26. Mayers, L. H.: Hemihypertrophy. Surg. Gynec. Obstet., XLIII, 746, 1926.
27. Meisenbach, R. O.: A Consideration of the Chemical and Mechanical Stimulation of Bone with Reference to the Epiphyseal and Diaphyseal Lines. Results of Animal Experimentation. Am. J. Orthop. Surg., VIII, 28, Aug. 1910.
28. Ollier, L.: Traité expérimental et clinique de la régénération des os et de la production artificielle du tissu osseux. Tome I. Paris, Masson et fils, 1867.
29. Pearse, H. E., Jr., and Morton, J. J.: The Stimulation of Bone Growth by Venous Stasis. J. Bone and Joint Surg., XII, 97, Jan. 1930.
30. Pearse, H. E., Jr., and Morton, J. J.: The Influence of Alterations in the Circulation on the Repair of Bone. J. Bone and Joint Surg., XIII, 68, Jan. 1931.
31. Phemister, D. B.: Operative Arrestment of Longitudinal Growth of Bones in the Treatment of Deformities. J. Bone and Joint Surg., XV, 1, Jan. 1933.
32. Poland, John: Traumatic Separation of the Epiphyses. London, Smith, Elder & Co., 1898.
33. Snyder, C. H.: Deformities Resulting from Unilateral Surgical Trauma to the Epiphyses. Ann. Surg., C, 335, 1934.
34. Speed, Kellogg: Growth Problems Following Osteomyelitis of Adolescent Long Bones. Surg. Gynec. Obstet., XXXIV, 469, 1922.
35. Speed, Kellogg: Longitudinal Overgrowth of Long Bones. Surg. Gynec. Obstet., XXXVI, 787, 1923.
36. Truesdell, E. D.: Inequality of the Lower Extremities Following Fracture of the Shaft of the Femur in Children. Ann. Surg., LXXIV, 498, 1921.
37. Wagstaffe, W. W.: On Lengthening of the Limb as a Result of Knee-Joint Disease. St. Thomas's Hosp. Report, X, 277, 1879.
38. Weber, F. P.: Unilateral Dwarfism of Limbs Connected with Congenital Multiple Chondromata. British J. Child. Dis., XVII, 85, 1920.
39. Wilensky, A. O.: Osteomyelitis: Its Pathogenesis, Symptomatology and Treatment. New York, The Macmillan Co., 1934.
40. Wilhelm, S. F.: Osteitis Fibrosa and the Hyperostotic Form of Bone Syphilis. A Comparative Anatomical and Roentgenological Study. Surg. Gynec. Obstet., XLI, 624, 1925.

STUDIES OF LONGITUDINAL GROWTH OF LONG BONES *

I. The Influence of Trauma to the Diaphysis

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Opinions are frequently expressed and evidence is occasionally offered to support the theories which are intended to explain the phenomena of bone growth. The exact nature of the physiological processes which regulate the rate and extent of long-bone growth are still mysteries. That certain factors, such as disease, trauma, or glandular dysfunction, may alter the rate and extent of bone growth is well known. Investigators do not agree in their attempts to explain: (1) why overgrowth of a long bone of a child occasionally occurs after fracture of the shaft; (2) why the epiphyses fuse to the shaft with complete cessation of longitudinal growth shortly after puberty; (3) what insults to the bones will consistently stimulate, retard, or arrest longitudinal growth; (4) what deformities may be predicted, following insult to the growing epiphyses; (5) how the epiphyses, themselves, grow; (6) through what biological mechanism acute or chronic systemic infections may alter the longitudinal growth of bone; (7) the relation between delayed puberty and delayed closure of epiphyseal lines of long bones; (8) the effect on rate or extent of longitudinal growth of bone or interruption of blood supply to the shaft, the metaphysis, or the epiphysis; (9) whether it is possible for the epiphysis, once destroyed, to regenerate and to function as a growth center; (10) why all long bones are preformed in cartilage and only a few bones of the head and face are formed in membrane.

Studies have been made and are being made in an attempt to throw some light upon these problems. This presentation is the first of a series of studies through which the writer and his associates hope to be able to add some information which will enable us to understand better the physiology of bone growth.

With the exception of the clavicle, all of the long bones composing the human skeleton are preformed in cartilage. They are preceded by masses of mesodermal cells which grow and differentiate into cartilaginous models of the subsequent osseous segments. By the end of the second month of intra-uterine life, the developing embryonic cartilage maps out the divisions of the skeleton. These segments, early in intra-uterine life, are required to support and to maintain the form for the soft-tissue structures which envelop them. Thus, they are subjected to forces of stress and strain, exerted by the maternal tissues and later by the muscles and

* Read at the Annual Meeting of the American Orthopaedic Association, Lincoln, Nebraska, June 3, 1937.

ligaments, which create functional demands for greater skeletal support. The cartilage phase in the formation of most of the bones may be a response to this demand placed upon the embryonic skeleton by the stresses and strains to which the forming extremities and spine are subjected during the interval preceding the deposition of mineral salts and transformation into bone.

Experimental evidence presented by Hales, Hunter, Duhamel, Ollier, Wegner, Humphry, Payton, von Kölliker, Haas, Gatewood and Mullen, J. D. Bisgard, and M. E. Bisgard indicates that all increase in length of the diaphyses of long bones, both prenatal and postnatal, occurs through enchondral growth by the multiplication of the cartilage cells of the juxta-epiphyseal region, on the shaft side of the epiphyseal-cartilage plate. As an individual approaches maturity, the epiphyseal cartilage becomes thinner, and finally the epiphysis fuses to the shaft, with subsequent cessation of all longitudinal growth. The Bisgards state, and Siegling has recently demonstrated, that the epiphysis grows in length from the articular cartilage and none of the longitudinal diameter of the epiphysis results from accretion of cartilage or bone from the epiphyseal side of the growth cartilage. The proportion of longitudinal growth from the two ends of a long bone is unequal, with the disproportion greater for growth occurring after birth.

The Bisgards confirmed the work of Digby and concluded that his measurements for the percentage of growth from each end of human long bones are accurate. These figures for the percentage of growth have been corroborated by the measurements of growth of human long bones from roentgenographically demonstrated transverse growth-arrest lines which Harris has shown may result from illness, malnutrition, trauma, or the feeding of phosphorus and other chemical poisons.

ATTEMPT TO STIMULATE OVERGROWTH OF BONE BY TRAUMA TO THE SHAFT

Ollier first noted that irritation of the shaft of a bone could cause increase in the rate of growth and that it might produce overgrowth of as much as one-fifteenth of the total length of the bone. Kishikawa recently reported a study of the effect of various irritants upon the longitudinal growth of the long bones. He found that constricting the limbs, preventing free venous flow, or ligation of the femoral veins caused some growth stimulation, so that, after eight weeks, on the side of operation there was an increase in longitudinal growth of the limb of 1.77 per cent. over that on the control side. Following an injection of oil of turpentine into the bone marrow at the distal end of the femur or into the knee joint in young rabbits, there was an increased growth on the side so treated of approximately 1 per cent. after six weeks and of 5 per cent. after sixteen weeks, as compared with the non-traumatized leg.

In 1933, Ferguson reported that the rate of longitudinal bone growth could be increased by direct trauma to the bone. He propounded the theory that the increased rate of bone growth that frequently occurs

following osteotomy or fracture of a long bone in a child results from interruption of the medullary blood supply to the metaphysis without interruption of the periosteal blood supply to the end of the shaft. He devised and performed an operation in which he drilled into the shaft of long bones "half-way from the epiphyseal line or lines to the middle of the bone", inserted a knife or curette, and disrupted the continuity of the medullary substance. He performed this operation in sixteen cases in which there was a short leg. In four cases in which such an operation was performed, seven bones were examined from three to five months later. He reported a gain in length of from one-sixteenth to one-eighth of an inch. Protocols were not given and the article does not state the cause or causes of the shortening.

Lambert has used Ferguson's methods of attempting to stimulate longitudinal bone growth eighteen times on patients, eight times on rabbits, and three times on dogs. He states: "While it has not been successful in increasing long-bone growth in every case (most notable of the failures were in a congenital fracture of the femur and in a spina bifida) most of them have shown some response." One patient showed a gain of three and four-tenths centimeters over a period of years following the operation. Whether or not other factors played a part in this was not discussed. Since neither Ferguson nor Lambert supplied protocols of their cases, the causes of shortening are not known. Orthopaedic surgeons are all familiar with the fact that during the pre-adolescent period of rapid growth a leg that is short because of paralysis from poliomyelitis often makes a definite gain in length as compared with the more normal

TABLE I

GROWTH STIMULATION FROM TRAUMA † IN RABBITS, AGED THREE WEEKS

Rabbit No.	No. of Days after Operation	Length of Tibia *		Length of Femur *		Difference in Length	
		Left (*Centimeters*)	Right (*Centimeters*)	Left (*Centimeters*)	Right (*Centimeters*)	Tibia (*Centimeters*)	Femur (*Centimeters*)
12.	48	7.2	7.2	6.8	6.7	0.0	0.1
13.**	48	7.2	7.1	6.0	6.5	0.1	−0.5
14.	48	7.6	7.6	6.8	6.8	0.0	0.0
15.	67	7.9	7.9	7.1	7.1	0.0	0.0
16.	73			7.1	7.1	0.0	0.0
17.	77			7.7	7.7	0.0	0.0

† On December 18, 1937, three holes were drilled through the left femur, completely disrupting the continuity of the medullary substance. There was no consistent growth change.

* Measurements from top of femoral head to tip of medial condyle and from tip of tibial spine to tip of medial malleolus.

** Femur fractured.

leg. This increased rate of growth is probably associated with improved muscle function. Clinical results which do not take this fact into consideration must be accepted with reservations. The theory which Ferguson has propounded to explain overgrowth that occurs following fracture or osteotomy of the long bones of a child fails to take into consideration the factor of hyperaemia in the traumatized limb.

Experiment I

An experiment was devised in which an attempt was made to traumatize the bone with minimal injury to the soft tissues. Rabbits, aged three weeks, were used. Without incision to expose the femur, three drill holes, the diameters of which were approximately that of the medullary canal of the femur, were made through both lateral and medial cortices, near the upper and lower metaphyses and in the mid-third of the shaft. The diameter of the drill was thus sufficient to remove approximately one-half of the cortical circumference and to disrupt effectively the medullary blood supply. The femur was so much weakened as a result of this procedure that in several instances a fracture occurred either at the time of operation or shortly afterward. Six rabbits so treated survived from forty-eight to seventy-seven days after operation. Roentgenograms were taken at intervals, but no evidence of growth stimulation was observed. The specimen removed at necropsy included both femora and both tibiae. These were measured accurately by means of calipers. (See Table I.) The femur of rabbit No. 12, which had been drilled, was found to be one millimeter longer than that of the control side. In rabbit No. 13 a fracture had occurred with slight displacement, which no doubt resulted in the shortening of five millimeters noted. Four rabbits, which survived from forty-eight to seventy-seven days, showed no difference in length of either the tibiae or the femora. This experiment would seem to us to indicate that trauma which is sufficient to interrupt medullary blood supply but not great enough to cause a regional hyperaemia during the period of bone repair will not consistently cause growth stimulation and overgrowth.

Although Speed, Broca, Truesdell, Cole, and David have described overgrowth of long bones in children following fractures, and Bisgard has demonstrated a similar overgrowth in experimental animals, the consensus of opinion of these observers has tended to coincide with that of earlier writers who believed that all longitudinal bone growth occurred from the epiphyses. David, Gatewood and Mullen, and Cole concluded that this growth stimulus was a compensatory phenomenon which came about as a result of shortening following fracture. The results of the studies of Bisgard and of our own observations definitely oppose this theory. Approximately the same degree of overgrowth occurs following a fracture in which union takes place without shortening, and hence it would not seem to be a compensatory mechanism. We have observed one instance

August 20, 1936
FIG. 1-A

September 8, 1936
FIG. 1-B

September 30, 1936
FIG. 1-C

November 12, 1936
(Specimen)
FIG. 1-D

Operation performed on a three-day-old rabbit on August 11, 1936. Both upper and lower metaphyseal regions of the femur were denuded and the round ligament was cut. Metal foil was placed in the medullary portion of the shaft. Note the formation of spindle-shaped new bone with progressive separation of the two pieces of metal foil, suggesting interstitial bone growth. Growth from the distal femoral epiphysis was arrested after three weeks.

of what appears to be interstitial bone growth. In an experiment which was performed to determine the effect upon bone growth of interrupting the circulation to the metaphyseal and epiphyseal regions, the lower end of the femur was completely denuded, the round ligament was cut, and the proximal metaphysis was stripped. This femur was then left with the blood vessels entering only the diaphysis. In order that a fixed point might be maintained from which to measure the growth from the two ends of the femur following such extensive trauma, a small amount of metal foil was inserted into the diaphysis. In one of the rabbits so treated two pieces of metal foil were used. This foil, together with the operative trauma, resulted in irritation and overproduction of bone, producing a spindlelike enlargement of the shaft. In subsequent roentgenographic observations over a period of three months (Figs. 1-A, 1-B, 1-C, and 1-D), the two pieces of metal foil became separated until they were approximately four millimeters apart. This observation indicated that either the metal foil had migrated in the medullary canal or interstitial longitudinal growth of bone had occurred at the site of irritation. This is quite contrary to the theories expressed by earlier workers, and certainly does not occur normally. Because of this observation, however, it was decided to repeat an experiment recently reported by Bisgard with regard to growth stimulation following fracture and, in particular, to determine whether or not the callus formed at the site of fracture, which contains varying amounts of cartilage, might contribute to the overgrowth of this bone.

Experiment II

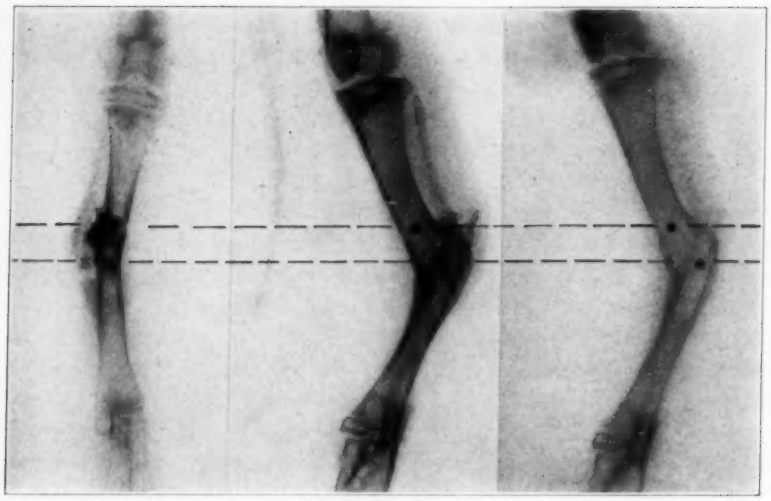
Twenty-one rabbits from three litters were used for this experiment. Of ten rabbits three days old (Group A), eight femora and two tibiae were

fractured between metal markers. Of seven rabbits five days old (Group B), one femur was fractured after metal points had been placed in the shaft near the metaphyseal regions; markers were placed in a second rabbit's femur, but the bone was not fractured; four tibiae were marked with metal points and fractured between; and one tibia with metal points was not fractured. *In none of these could we demonstrate any separation of the markers*, although an abundant callus formed in connection with the healing of the fracture. In Group C four rabbits, seven weeks old, were used. An open operation was performed, and metal shot were inserted in drill holes in the cortex of the bone, the defects in the bone being such that the shot were held firmly in position. These shot were placed two centimeters apart by accurate measurements. The shaft of the tibia was then fractured between the shot. The fracture was reduced and fixed in an end-to-end position. Roentgenograms were taken, using a carefully standardized technique, at intervals of two weeks. Specimens were obtained at necropsy of two rabbits after one month and of the remaining two rabbits after seven weeks.

In rabbit No. 2, the alignment of the fractured bone was well maintained. As a result of the fracture, there was an immediate shortening of one and seven-tenths millimeters. After five weeks, this fractured tibia was found to be two millimeters longer than its mate, a total gain of

FIG. 2

Experiment 11. Rabbit 2. Before the tibia was fractured, two shot, spaced two centimeters apart, were embedded in the cortex. Loss of substance or impaction of the reduced fracture resulted in immediate shortening of one and seven-tenths millimeters. Seven weeks later the distance between the two markers had increased by six-tenths of a millimeter. Since a similar separation of markers did not occur in other rabbits of the series, it would seem reasonable to assume that this was the result of slight separation of the fracture ends during the process of healing rather than of interstitial growth. Measurements made after necropsy showed that the fractured tibia was two millimeters longer than the normal control. This indicated a total epiphyseal-growth stimulation of three and one-tenth millimeters.



April 7, 1937 April 26, 1937 May 11, 1937

FIG. 3

Experiment II. Rabbit 4. No interstitial bone growth or growth from cartilage of fracture callus in the presence of overriding and angulation.

more than three millimeters (Fig. 2). During the succeeding two weeks, however, this growth stimulus seems to have been lost, and the normal tibia made a gain of five-tenths of a millimeter. Since the fracture was well united at the end of five weeks, this observation suggests that the growth stimulus only lasts until healing is complete, after which there may be a tendency for the normal and temporarily short bone to catch up. The final measurement of distance between the metal shot shows them to be approximately six-tenths of a millimeter farther apart than immediately after fracture.

In rabbit No. 4, some displacement and angulation occurred at the site of the fracture, with abundant production of callus. No longitudinal growth occurred in the diaphysis or at the site of the fracture (Fig. 3). This experiment definitely casts a doubt upon the interpretation of interstitial growth demonstrated in Figures 1-A, 1-B, 1-C, and 1-D. The results are in accord with those of Bisgard in showing that overgrowth of bone may occur following fracture without a significant decrease in length from over-riding, displacement, or the loss of a segment of the shaft of the bone. The longitudinal overgrowth of bone following fracture of the shaft occurs entirely from stimulation of the epiphyseal growth cartilage and not from the cartilage of the fracture callus of interstitial diaphyseal elongation.

STIMULATION OF OVERGROWTH FOLLOWING REMOVAL OF TIBIAL BONE GRAFT

Our studies showed that minimal trauma to the diaphysis did not cause overgrowth, while fracture or osteotomy produced stimulation of

TABLE II

GROWTH STUDIES ON TIBIAE FROM WHICH BONE GRAFTS HAVE BEEN TAKEN

Case No.	Name	Age at Operation (*Years*)	Time after Operation	Measurements Taken *	Operated Side (*Centimeters*)	Non-Operated Side (*Centimeters*)	Difference (*Centimeters*)	Comments
1.	R. K.	3	3 years	Growth line (1)† laid down approximately one year after operation.				
				Tibia: diaphysis	19.6	19.2	0.4	Overgrowth of 0.4 of a centimeter on operated side one year following operation, with equal growth since.
				Fibula: diaphysis	19.0	18.8	0.2	
				Tibia: proximal G. L. (1) to distal G. L. (1)	16.0	15.6	0.4	
				proximal G. L. (1) to proximal E. L.	1.9	1.9	0.0	
				distal G. L. (1) to distal E. L.	1.8	1.8	0.0	
2.	D. Y.	6	6 years	Tibia: diaphysis	29.0	29.2	−0.2	No overgrowth. Osteoperiosteal graft only was removed from this tibia.
				Fibula: diaphysis	28.0	28.2	−0.2	
				Tibia: distal G. L. (1) to distal E. L.	1.2	1.2	0.0	
				distal G. L. (2) to distal E. L.	3.7	3.7	0.0	
				distal G. L. (3) to distal E. L.	4.1	4.1	0.0	
				distal G. L. (4) to distal E. L.	6.4	6.4	0.0	
3.	R. J.	14	6 months	Tibia: diaphysis	38.8	38.7	0.1	Overgrowth of 0.1 of a centimeter in six months.
				Fibula: diaphysis	34.5	34.4	0.1	
4.	D. S.	5	6 years	Tibia: diaphysis	28.0	27.5	0.5	Overgrowth of 0.5 of a centimeter. Tibia of operated side overgrew fibula 0.4 of a centimeter. Osteoperiosteal graft.
				Fibula: diaphysis	27.3	27.2	0.1	
				Tibia: distal G. L. (1) to distal E. L.	1.1	1.1	0.0	
				distal G. L. (2) to distal E. L.	1.6	1.6	0.0	
				distal G. L. (3) to distal E. L.	2.5	2.5	0.0	
				distal G. L. (4) to distal E. L.	3.2	3.0	0.2	
				distal G. L. (5) to distal E. L.	4.7	4.4	0.3	
5.	M. S.	8	2 years	Tibia: diaphysis	25.7	25.4	0.3	Overgrowth of 0.3 of a centimeter following operation, with equal growth since. Some tendency recently to compensate.
				Fibula: diaphysis	25.5	25.5	0.0	
				Tibia: proximal G. L. (1) to proximal E. L.	1.6	1.7	−0.1	
				proximal G. L. (2) to proximal E. L.	4.7	4.6	0.1	
				distal G. L. (1) to distal E. L.	1.2	1.2	0.0	
				distal G. L. (b) to distal E. L.	2.9	2.9	0.0	
				distal G. L. (c) to distal E. L.	5.8	5.7	0.1	
6.	M. M.	5	6 months	Tibia: diaphysis	20.5	20.4	0.1	Overgrowth of 0.1 of a centimeter in six months following operation.
				Fibula: diaphysis	19.8	20.0	−0.2	
7.	S. M.	2½	6 months	Tibia: diaphysis	14.2	14.0	0.2	Overgrowth of 0.2 of a centimeter in six months following operation.
				Fibula: diaphysis	14.2	14.3	−0.1	
				Femur: distal G. L. (1) to distal E. L.	0.8	0.8	0.0	
				Tibia: proximal G. L. (1) to proximal E. L.	0.5	0.4	0.1	
				distal G. L. (1) to distal E. L.	0.5	0.4	0.1	
				proximal G. L. (1) to distal G. L. (1)	13.5	13.5	0.0	
				Fibula: proximal G. L. (1) to proximal E. L.	0.4	0.4	0.0	
8.	C. C.	8	3 years	Tibia: diaphysis	31.6	31.0	0.6	Overgrowth of 0.8 of a centimeter or more following operation. Recent more rapid overgrowth of the non-operated side.
				Fibula: diaphysis	31.3	30.7	0.6	
				Tibia: distal G. L. (2) to proximal E. L.	28.8	28.0	0.8	
				distal G. L. (1) to distal E. L.	2.4	2.6	−0.2	
				distal G. L. (2) to distal E. L.	2.8	3.0	−0.2	

* Abbreviations: G. L. = Growth Line; E. L. = Epiphyseal Line.

† Growth lines are numbered beginning nearest the epiphyseal lines and proceeding toward the diaphysis.

longitudinal growth. This suggested that complete loss of continuity of the bones might be required to produce sufficient stimulation to cause overgrowth.

The trauma to a tibia incident to removal of a bone graft was next studied. The length of the tibiae of growing children who had been subjected to operations such as spine fusion, in which it was necessary to remove full-thickness cortical or heavy osteoperiosteal grafts from one tibia, was determined by roentgenographic measurements. Table II shows the results of measurements made on a series of eight patients. No

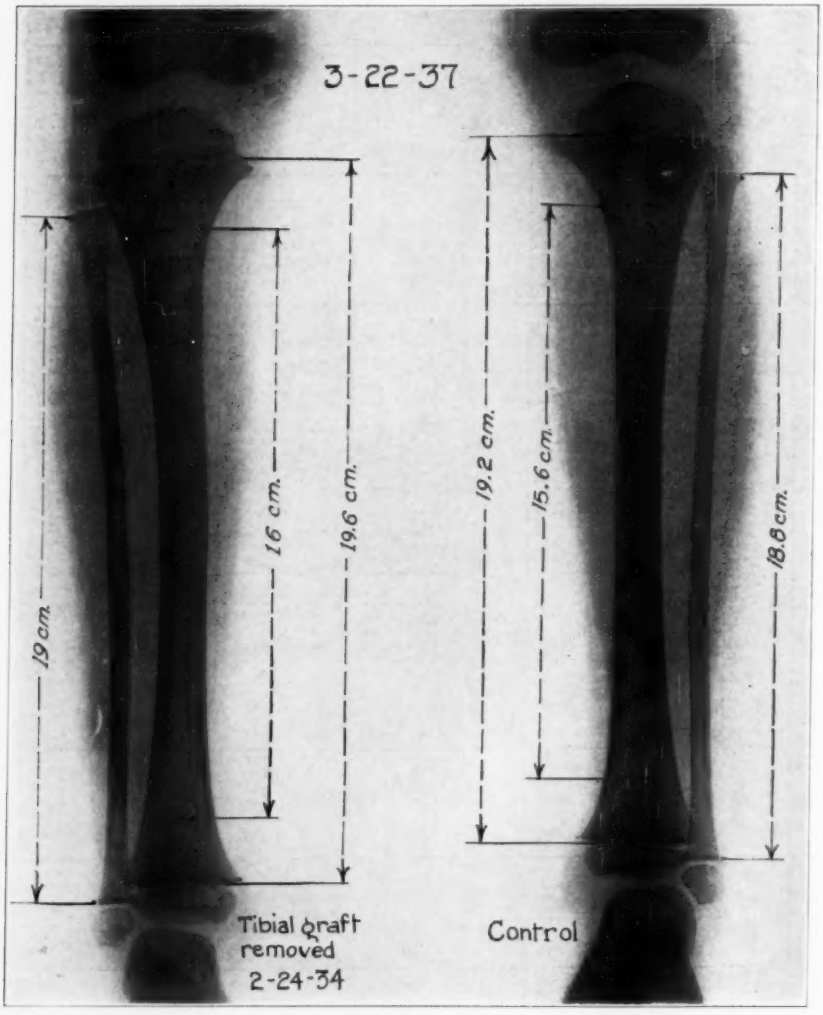


FIG. 4

Case 1 (Table II). Longitudinal overgrowth of tibia and fibula, following removal of full-thickness cortical bone graft. Increased rate of growth no longer present after one year from the time of operation, as shown by transverse growth-arrest lines.

attempt was made to compare the lengths of two tibiae in cases where there was any coexistent history of disease in the hip joint. In each instance in which the tibia had been insulted by the removal of a full-thickness cortical graft, overgrowth occurred. In only one of the patients, Case 2, was there failure of the operated limb to grow longer than the normal. In this case, only an osteoperiosteal graft had been removed.

Roentgenograms of Case 1 (Fig. 4) show that overgrowth of four-

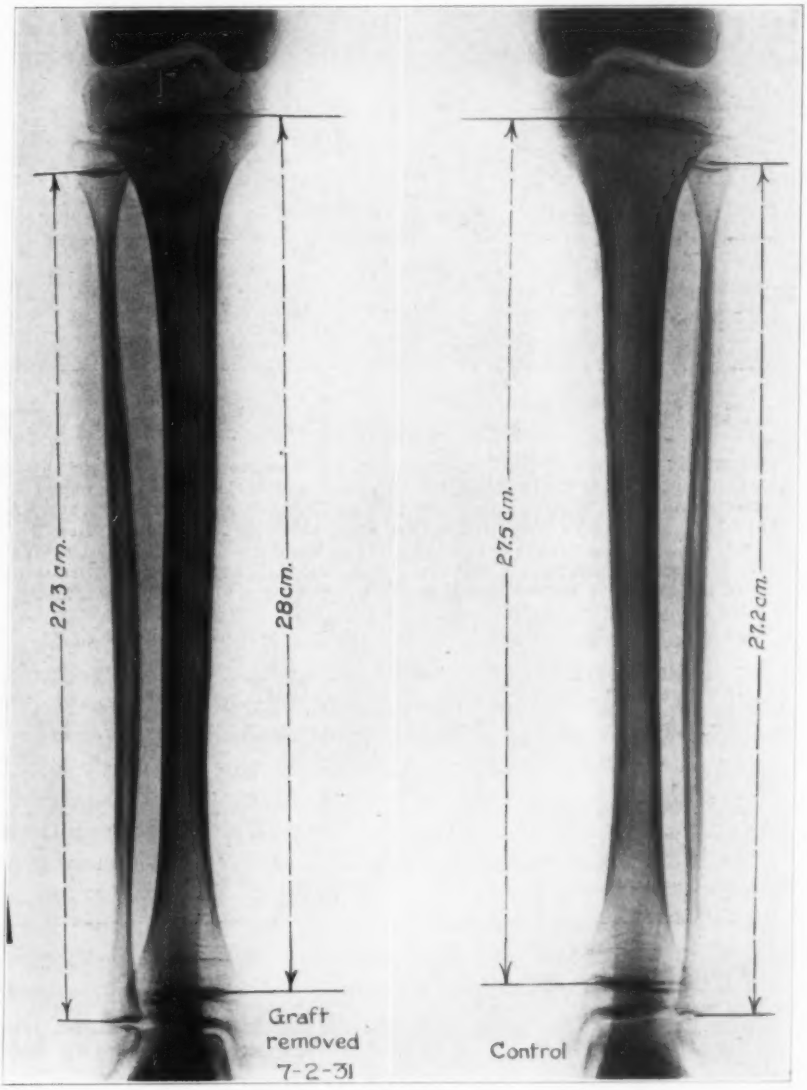
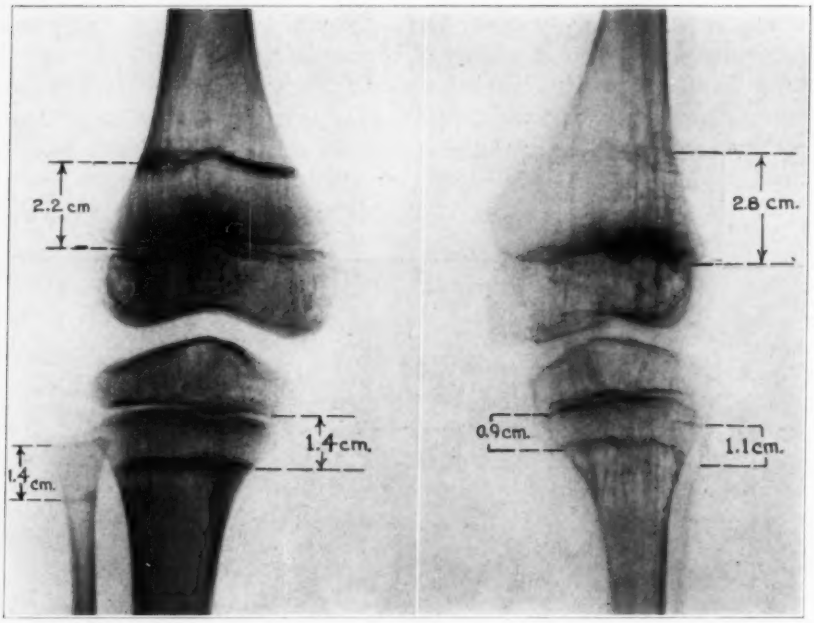


FIG. 5

Case 4 (Table II). April 11, 1937. Longitudinal overgrowth as a result of operation for removal of tibial bone graft. A difference of five-tenths of a centimeter in the tibial length is still present six years after operation.



Right
October 26, 1936

Left
October 26, 1936

FIG. 6

Growth stimulation of distal femoral epiphysis as a result of disease and operative trauma (arthrodesis of left hip, June 29, 1934, and insertion of tibial bone graft). Growth from the distal femoral epiphysis is six-tenths of a centimeter greater than that of the same epiphysis of the normal leg. Note that growth stimulus of the normal tibia is greater than that of the side of the disease. This may be due, in part, to atrophy of disuse of the tibia of the diseased leg; in part, to growth stimulation of the normal tibia as a result of removing a bone graft two years and four months earlier.

tenths of a centimeter had occurred in the tibia and of two-tenths of a centimeter in the fibula. Since the fibula was not exposed during the operation, this growth stimulus could be accounted for only by the hyperaemia which resulted from the operation or as secondary to the growth stimulus in the tibia. The growth-arrest lines shown in the roentgenograms were laid down less than a year from the time of operation as a result of an acute secondary infection. All of the increased growth was found to have occurred during this first year. The amount of longitudinal growth which occurred during the succeeding two years had been identical in the two tibiae. This is further evidence that the growth stimulus resulting from trauma to long bones lasts only until healing of the defect in the bone.

Roentgenograms of Case 4 (Fig. 5), made six years after removal of a tibial graft, show that there is still present an overgrowth of five-tenths of a centimeter in the operated tibia and of one-tenth of a centimeter in the fibula. The most marked degree of overgrowth was that of Case 8 in which overgrowth of eight-tenths of a centimeter occurred within a few

months following operation. A growth-arrest line was then laid down, following an intercurrent infection. Subsequent to this incident, the normal tibia gained two-tenths of a centimeter as compared with the operated leg. This suggests that, following growth stimulation as a result of trauma, the growth rate may lag for a time in the operated limb, permitting the normal limb, which is growing at the normal rate, to gain in relative length.

GROWTH STIMULATION FROM AMPUTATION OR EXTENSIVE TRAUMA TO PROXIMAL END OF FEMUR

Selye has demonstrated the ability of very young rats to regenerate epiphyses at the amputation end of long bones, and he concludes that such regenerative epiphyses will contribute to long-bone growth. In the rats over five weeks of age at the time of amputation this regeneration did not occur. Mullen and Gatewood demonstrated marked stimulation of epiphyseal growth in rabbits following amputation. Markers were placed in both femora at the time of amputating in the mid-thigh region. The epiphyseal growth of the remaining epiphyses of the femur of the amputated leg overgrew the control epiphyseal plates from one millimeter to nine millimeters in seven of ten rabbits. There was no evidence of any growth in the diaphyses, and a definite tendency for absorption of the end of the stump was noted. These experimental studies stimulated us to review some of our clinical cases in which traumatizing operations had been performed at the hip, to determine whether or not this produced any growth stimulation of the distal femoral epiphysis. As no markers had been placed in these femora, we had to depend upon the presence of growth-arrest lines. Figure 6 shows the distal ends of the femora of a patient with tuberculosis of the left hip, who was operated on in 1934, at the age of six years. The left hip was arthrodesed by means of partial excision and a tibial bone graft which was taken from the right tibia. This patient was given phosphorized cod-liver oil for several weeks following the operation, and heavy transverse growth-arrest lines were laid down. From the time of the laying down of these lines, which approximately coincided with the operation on the hip, there was overgrowth of six-tenths of a centimeter from the distal end of the operated left femur. This was in spite of the fact that this limb showed marked atrophy of disuse, resulting from disease in the hip over a period of nearly four years. As evidence of the fact that this over-growth did not occur because of absence of weight-bearing, the growth from the proximal end of the tibia on the side of the diseased hip is less than that on the normal side. Again, we have the possible factor of growth stimulation due to the trauma resulting from taking a tibial graft from the normal right leg, which presumably accounts in part for the overgrowth of that tibia as compared with the left. This, too, would indicate that growth stimulation as a result of trauma to one bone does not affect other bones in the same extremity to the same degree.

DISCUSSION

The consensus of opinion of investigators and of clinical observers has been that there is no length growth from the diaphysis, even when the growth rate of a long bone is increased following injury, such as may occur from trauma or disease. Our studies confirm those of Bisgard that overgrowth may occur following fracture of a long bone in the absence of any shortening from overriding of the fragments or loss of a portion of the shaft. Our experimental studies show that this increased rate of growth occurs from the epiphysis and not from the diaphysis or the cartilaginous callus which forms at the site of the fracture. In only one experimental animal was there an apparent increase in length of the diaphysis at the site of fracture and this was too small an amount to be significant. Overgrowth may occur from gross mechanical trauma to the long bone without fracture, and the amount of increased growth depends to some extent upon the degree of the trauma and the rapidity of repair of the defect in the traumatized bone. It does not depend upon interruption of the medullary blood supply. The placing of three drill holes, of the diameter of the medullary canal, through the shaft of a long bone does not afford sufficient stimulus to cause a consistent or definite increased rate of growth in that bone. The removal of a full-thickness tibial bone graft from the young child does cause sufficient growth stimulus to produce some overgrowth in the bone so insulted. This increased rate of growth does not last more than a few months, apparently continuing until repair of the defect is complete. Some overgrowth may occur in the fibula of the operated leg, but this is less than that in the tibia. Longitudinal overgrowth as a result of gross mechanical trauma to one long bone does not occur in bones of other segments of that extremity.

Studies which show growth stimulation and an increase in length of the traumatized limb over the normal, when there is no increased functional demand placed upon the extremity because of shortening, would seem to disprove the conclusion that the stimulus which occurs following fracture with overriding is compensatory in nature. Overgrowth produced by chronic inflammation in the bones of an extremity (without actual destruction of the epiphysis or of the growth-cartilage plates) can best be explained on the basis of local hyperaemia, and in all probability the growth stimulus which occurs following mechanical trauma, such as fracture or excision of bone grafts, should be explained in the same way. Further evidence of this theory may be found in the cases of marked overgrowth of an extremity associated with arteriovenous aneurysm.

CONCLUSIONS

1. Minimal trauma to the shaft or to the metaphysis of a long bone, with or without interruption of the medullary blood supply, does not produce any definite increase in rate or extent of longitudinal bone growth.

2. Gross trauma, involving a considerable portion of the shaft of a

long bone and necessitating extensive repair over a long period of time, does produce epiphyseal stimulation and longitudinal overgrowth.

3. The increased rate of growth continues only during the period of healing.

4. This growth stimulation appears to be secondary to the hyperaemia and increased vascularity of the bone and soft parts following the trauma and during the process of healing.

5. The longitudinal overgrowth which may accompany a fracture occurs regardless of whether or not there is initial shortening as a result of overriding or loss of shaft substance. This observation, together with the fact that overgrowth may also occur after gross trauma without loss of continuity of the shaft of a bone, such as excision of a full-thickness tibial bone graft, is further evidence to support the theory of local hyperaemia as the basic stimulus and that it is *not* a *compensatory phenomenon.*

6. Evidence that longitudinal bone growth may occur from the diaphysis or from the cartilage of the callus following fracture of the shaft is not well supported by the data presented.

7. Chronic localized inflammation of the diaphysis, due to an irritant foreign body, may result in marked bone proliferation with increased diameter of the shaft. There is some evidence that under these circumstances localized interstitial longitudinal growth may occur. This possibility is deserving of further investigation.

REFERENCES

Bisgard, J. D.: Longitudinal Overgrowth of Long Bones with Special Reference to Fractures. Surg. Gynec. Obstet., LXII, 823, 1936.

Bisgard, J. D., and Bisgard, M. E.: Longitudinal Growth of Long Bones. Arch. Surg., XXXI, 568, 1935.

Broca, P.-P.: Remarques sur les fractures spiroïdes et sur les régénérations osseuses. Rapport sur une observation de M. Descroizilles, lu à la Société anatomique le 24. juin 1859. Paris, Victor Masson, 1859.

Cole, W. H.: Results of Treatment of Fractured Femurs in Children with Especial Reference to Bryant's Overhead Traction. Arch. Surg., V, 702, 1922.

Compensatory Lengthening of the Femur in Children after Fracture. Ann. Surg., LXXXII, 609, 1925.

David, V. C.: Shortening and Compensatory Overgrowth Following Fractures of the Femur in Children. Arch. Surg., IX, 438, 1924.

Digby, K. H.: The Measurement of Diaphysial Growth in Proximal and Distal Directions. J. Anat. and Physiol., L, 187, 1915–1916.

Duhamel, H. L.: Cinquième mémoire sur les os. Mémoires de l'Académie Royale des Sciences, p. 111, 1743.

Ferguson, A. B.: Surgical Stimulation of Bone Growth by a New Procedure. J. Am. Med. Assn., C, 26, 1933.

Gatewood, and Mullen, B. P.: Experimental Observations on the Growth of Long Bones. Arch. Surg., XV, 215, 1927.

Epiphyseal Growth as Cause of Conical Amputation Stump Formation. Western J. Surg., XXXVIII, 513, 1930.

Haas, S. L.: Interstitial Growth in Growing Long Bones. Arch. Surg., XII, 887, 1926.

Hales, Stephen: Statistical Essays. Vol. I, p. 337. London, 1727.

HARRIS, H. A.: Lines of Arrested Growth in the Long Bones in Childhood: The Correlation of Histological and Radiographic Appearances in Clinical and Experimental Conditions. British J. Radiol., IV, 561, 1931.

HUMPHRY, G. M.: Observations on the Growth of the Long Bones, and of Stumps. Med. Chir. Trans., XLIV, 117, 1861.

HUNTER, JOHN: Experiments and Observations on the Growth of Bones, From the Papers of the Late Mr. Hunter. *In* The Works of John Hunter, with Notes. Edited by James F. Palmer. Vol. IV, p. 315. London, 1837.

KISHIKAWA, E.: Studien über einige lokale Reize, welche das Längenwachstum des Langröhrenknochens steigern. Fukuoka Acta Med. (Abstract Sect.), XXIX, 4, 1936.

VON KÖLLIKER, ALBERT: Die normale Resorption des Knochengewebes und ihre Bedeutung für die Entstehung der typischen Knochenformen. Leipzig, F. C. W. Vogel, 1873.

LAMBERT, C. N.: Personal communication.

OLLIER, L.: Traité expérimental et clinique de la régénération des os et de la production artificielle du tissu osseux. Tome I. Paris, V. Masson et fils, 1867.

PAYTON, C. G.: The Growth in Length of the Long Bones in the Madder-Fed Pig. J. Anat., LXVI, 414, 1931–1932.

PHEMISTER, D. B.: Bone Growth and Repair. Ann. Surg., CII, 261, 1935.

PIERSOL, G. A.: Human Anatomy. Ed. 8, p. 94. Philadelphia, J. B. Lippincott Co., 1920.

SELYE, HANS: On the Mechanism Controlling the Growth in Length of the Long Bones. J. Anat., LXVIII, 289, 1934.

SIEGLING, J. A.: Studies on the Development and Growth of the Epiphyses of the Long Bones. Proc. Inst. Med., II, 286, 1937.

SPEED, KELLOGG: Longitudinal Overgrowth of Long Bones. Surg. Gynec. Obstet., XXXVI, 787, 1923.

TRUESDELL, E. D.: Inequality of the Lower Extremities Following Fracture of the Shaft of the Femur in Children. Ann. Surg., LXXIV, 498, 1921.

WEGNER, GEORG: Ueber das normale und pathologische Wachsthum der Röhrenknochen. Eine kritische Untersuchung auf experimenteller und casuistischer Grundlage. Virchows Arch. f. Path. Anat., LXI, 44, 1874.

ISCHIOPUBIC OSTEOCHONDRITIS

BY HERBERT A. DURHAM, M.D., SHREVEPORT, LOUISIANA

Osteochondritis of the epiphysis of the ischiopubic junction was first described in 1924 by Van Neck who had observed five patients. In the same year Odelberg published his experience with four patients. He was followed in 1925 by Valtancoli and in 1926 by Wülfing, each author reporting five cases. In 1930 two more articles appeared,—one by Asplund and one by Davidson. The latest contribution is that by Torgersen who reported two cases in September 1936. As far as can be ascertained, there are no accounts of personal observations in the English literature, although King, in his excellent monograph on localized rarefying conditions of bone, gives a brief description of the condition. In view of this fact it seems well worth while to analyze briefly a series of five patients observed in the past seven years.

CASE REPORTS

CASE 1. A white boy, eight years old, was brought to the hospital because of pain in the left hip and inability to walk. The pain had been present two weeks and was referred at times to the left knee. There was no history of immediately preceding injury or infection, but three months before the onset the boy had had an attack of "influenza".

The hip was held in 135 degrees of flexion with motion greatly restricted by muscle spasm. Tenderness was very pronounced over the descending ramus of the left pubis. There was questionable tenderness about the hip joint proper, but no swelling or redness. The blood count showed a leukocytosis of 21,400 with 80 per cent. polymorphonuclears. Other laboratory tests, including blood Wassermann reaction, gave no significant information. Roentgenograms showed an area of rarefaction with roughening and thickening at the junction of the descending pubic ramus and the ischium on the left side.

The tonsils were regarded as a possible focus of infection and were removed. The orthopaedic treatment consisted of recumbency on a Bradford frame with traction to the left hip. Pain and muscle spasm subsided very rapidly and, on discharge, nine weeks later, the patient had normal motion in the hip and walked without a limp. He has remained well since. Subsequent roentgenograms show complete regeneration of the ischiopubic junction.

The following report is contributed by Dr. Robert C. Robertson of Chattanooga, Tennessee.

CASE 2. A white boy, seven years old, was brought to the office because of pain in the left side of the pelvis. The pain had been present for nine days and had followed a wrestling bout in which the left hip was pressed against a rock. Fever had ranged up to 103.5 degrees. There was no history of infectious disease antedating the injury.

The boy walked with a limp, the hip and knee were held slightly flexed, and great tenderness existed over the ischial tuberosity. Laboratory tests showed no abnormal findings except for a leukocytosis of 20,400 with a polymorphonuclear count of 83 per cent. Roentgenograms showed an irregular area of roughening with rarefaction at the junction of the descending pubic ramus and the ischium on the left side.

Hot, wet dressings were applied and the patient was kept in bed for six weeks. During this time he was afebrile and symptomless, and he has remained so on resuming

activity. Limitation of motion has disappeared entirely, but some palpable thickening persists about the ischial tuberosity.

CASE 3. A white girl, aged five years, was seen because of intermittent pain in the left hip, sufficient to make her limp. This had been present off and on for several weeks. There had been no injury, infectious disease, or fever.

The hip had a full range of motion with slight muscle spasm on extreme flexion and

FIG. 1-A

Case 1. Lesion of ischiopubic junction during acute stage.

FIG. 1-B

Case 1. Healed ischiopubic junction one year later.

very definite spasm on rotation and abduction. The descending ramus of the pubis and the ischiopubic junction were tender, but the hip joint itself was not. Roentgenograms showed roughening and thickening at the junction of the ischium and the descending ramus of the pubis on the left. The patient was put to bed with traction to the left leg for four weeks and kept in bed without traction for an additional three weeks. At the end of that time all symptoms and physical signs had disappeared and a roentgenogram revealed complete fusion at the ischiopubic junction.

CASE 4. A white girl, aged seven years, came to the hospital with a complaint of

FIG. 2-A

Case 2. Lesion of ischiopubic junction during acute stage.

FIG. 2-B

Case 2. Healed ischiopubic junction three months later.

pain in the right hip and inability to walk. The pain had been present about two weeks and had followed an attack of otitis media by an interval of a few days. There was no history of injury. The family history indicated that the father had active pulmonary tuberculosis.

The hip was held in 135 degrees of flexion and 20 degrees of abduction. All motion was restricted by intense muscle spasm. The descending pubic ramus was very tender. The hip joint itself was free from tenderness, redness, or swelling. Laboratory tests revealed only a leukocytosis of 16,700 with 83 per cent. polymorphonuclears. The roentgenogram showed an area of rarefaction with thickening and irregularity at the junction of the descending ramus of the right pubis and the ischium. The same condition was present to a lesser degree on the left, but without producing any symptoms. The temperature was 102 degrees on admission, but returned to normal in three days.

FIG. 3-A

Case 3. Lesion of ischiopubic junction during acute stage.

FIG. 3-B

Case 3. Healed ischiopubic junction ten weeks later.

The tonsils were regarded as a possible focus of infection and were removed. The patient was placed on a Bradford frame with traction to the right leg for six weeks, and kept in bed an additional two weeks. She recovered a full range of painless motion at the hip and has had no recurrence. Final roentgenograms show complete fusion of the ischium and pubis.

FIG. 4-A

Case 4. Lesions of ischiopubic junctions during acute stage.

FIG. 4-B

Case 4. Healed ischiopubic junctions nine months later.

FIG. 5

Case 5. Lesion of ischiopubic junction during acute stage.

CASE 5. A white boy, eight years old, was brought to the hospital because of pain in the left hip and inability to walk. He came from a sheltering home and no detailed history could be obtained.

The hip was not limited in motion, but gave evidence of muscle spasm on extreme flexion and abduction. The descending ramus of the pubis was tender. Roentgenograms showed rarefaction and roughening at the left ischiopubic junction.

The general examination revealed that the boy was acutely ill with bronchopneumonia. For this reason he was transferred to the Charity Hospital, where he died the following morning. No autopsy was performed.

Although the data in this case are inadequate for complete study, they are included to illustrate the condition further. It is of interest that the child was brought to the hospital because of pain in the hip and that the acute pulmonary condition was completely overlooked.

DISCUSSION

Ischiopubic osteochondritis occurs only during the first decade of life, since the conjoined rami of the ischium and pubis are completely ossified and fused by the tenth year. The average age of the patients in this series is seven and one-half years.

Little is known about the etiology. There has been much speculation, but very little factual proof. Probably the two factors which have been given the greatest amount of consideration as causative agents are trauma and infection, with the weight of evidence in favor of the former. Children at play are constantly exposed to varying degrees of injuries because they have not yet developed the instinct of self-protection. This is well illustrated by the fact that football injuries are more common among children than among college students. It is altogether likely, even though not always plainly evident from the history, that patients who develop osteochondritis have suffered sufficient strain to affect the susceptible epiphyseal region. A history of definite trauma was obtained

from one patient in this series and a history of suspected trauma in another; in the remaining three, no statement was made regarding injury. In several of Wülfing's patients cultures were taken from the lesions, but these failed to produce definite results. No cultures were taken from any patients in this series. A clear history of antecedent infection was elicited in only one. In this patient an acute attack of otitis media was followed in a few days by the symptoms of osteochondritis. Two patients had enlarged and infected tonsils, but it is questionable whether the tonsillectomies had anything to do with the resolution of the epiphysitis.

The diagnosis should offer no particular difficulty if the possibility of the existence of this lesion is kept in mind. The symptoms and findings on physical examination are quite typical. Pain referable to the hip or groin is essentially present. The child walks with a definite limp and protects the affected side, if the pain is not so acute as to prevent weight-bearing altogether. Tenderness along the descending ramus of the pubis, with or without swelling, is characteristic and immediately suggests the diagnosis. Muscle spasm, particularly of the adductors, is constantly present in varying degrees. No swelling or tenderness is demonstrable about the hip joint. The temperature may be within normal limits or it may be elevated. Moderate leukocytosis is usually present. The roentgenogram is typical and establishes the diagnosis.

The treatment is essentially the same as that for allied bone-growth disturbances and consists of recumbency with sufficient traction to the affected leg to overcome muscle spasm. In the patients here reported the lesion responded rapidly to such care and eventually resolved completely by ossification of the ischiopubic junction.

Ischiopubic osteochondritis is of clinical importance in that it may simulate hip-joint disease very closely, both in symptoms and in signs, and, if one is not mindful of the possibility of epiphysitis in the ischiopubic region, the lesion might easily be overlooked. Another diagnostic pitfall is confusion with acute osteomyelitis, which has clinical manifestations in common with osteochondritis. In both diseases, local tenderness, fever, and leukocytosis are characteristic. Swelling and redness, however, are more often found in osteomyelitis than in osteochondritis. The general appearance of the patient is of some significance; it is more apt to bear evidence of a systemic reaction in osteomyelitis. The roentgenogram will usually decide the matter. In osteochondritis, the characteristic change is rarefaction with roughening and thickening; in acute osteomyelitis, one would look for a destructive lesion with periosteal reaction. The differentiation is very important because the treatment of osteochondritis consists of rest, while that of osteomyelitis is usually surgical.

SUMMARY

In the five cases of ischiopubic osteochondritis described, the average age of the patients was seven and one-half years. No further light is shed on the etiology, but the belief is expressed that of the two factors, trauma

and infection, the former is the more important. The symptoms were principally limitation of motion of the hip and tenderness along the pubic ramus. The roentgenograms showed rarefaction, roughening, and irregularity at the ischiopubic junction. The treatment consisted of recumbency and traction to the affected hip. Recovery was complete, clinically and roentgenographically, in every patient except one, who died of intercurrent pneumonia.

REFERENCES

ASPLUND, G.: A Few Cases of Ischio-Pubic Osteochondritis. Acta Chir. Scandinavica, LXVII, 1, 1930.

DAVIDSON, WHATELY: Radiological Appearances and Clinical Significance of Osteochondritis Ischio-pubica. Acta Pediat., XI, 233, 1930.

KING, E. S. J.: Localized Rarefying Conditions of Bone as Exemplified by Legg-Perthes' Disease, Osgood-Schlatter's Disease, Kümmell's Disease and Related Conditions. p. 262. Baltimore, William Wood & Co., 1935.

ODELBERG, A.: Some Cases of Destruction in the Ischium of Doubtful Etiology. Acta Chir. Scandinavica, LVI, 273, 1923–1924.

TORGERSEN, J.: Ischiopubic Osteochondritis. Norsk Mag. f. Laegevidensk., XCVII, 951, 1936.

VALTANCOLI, G.: Osteochondrite ischio-pubica. Chir. d. Org. di Movimento, IX, 281, 1925.

VAN NECK, M.: Ostéochondrite du pubis. Arch. Franco-Belges de Chir., XXVII, 238, 1924.

WÜLFING, MAX: Über Osteochondritis ischio-pubica. Deutsche Ztschr. f. Chir., CXCIX, 413, 1926.

A RECONSTRUCTION OPERATION FOR OLD UNUNITED FRACTURE OF THE FEMORAL NECK *

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This report is based upon a review of fifteen cases of old ununited fracture of the neck of the femur in which a previously described type of reconstruction operation [1] has been done. Very briefly, the essential features of this reconstruction operation are: (1) The sectioning, close to their insertions, of all the muscles attached to the region of the greater trochanter, preserving a thin layer of fibromuscular tissue over the upper end of the bone; (2) the removal of the loose head; and (3) the placing of the upper extremity of the femur deeply and firmly within the acetabulum and transplanting of the gluteus medius and the gluteus minimus group of muscles downward on the shaft of the femur as far as they will reach, securely fastening them to the underlying bone.

In considering the treatment recommended for the type of fracture under discussion, it would seem feasible to take up the problem under three heads:

1. The restoration of stability.
2. The maintenance of a satisfactory range of movement.
3. The increase in length of an already shortened extremity.

1. The restoration of stability: That instability is a prominent feature in these old cases and doubtless is the cause of a great deal of the pain which these patients suffer is well recognized. In the ununited case, with neck absorption, the weight of the body may be wholly supported by the soft tissues about the hip or by the bony spicules which engage one another insecurely. These factors produce pain and add to the already difficult problem of weight-bearing. In many of these cases in which absorption of the neck is noted at operation, nature has often covered the inner surface of the bone in the region of the absorbed neck with dense fibrous tissue, but if any protruding spicules of the neck are found they are chiseled off flush with the inner surface of the shaft and the raw bony area covered with adjacent soft tissue. If the upper end of the femur is inserted deeply within the acetabulum, the line of thrust is placed directly under the pelvis in the manner of a crutch, and a considerable degree of stability is secured. The stability of the reconstructed hip is thought to be also dependent upon the strong fascia of the thigh, and upon the integrity of the new insertion of the abductor muscles. Therefore, the gluteus medius and the gluteus minimus muscles must be carefully secured into the bony trough on the lateral aspect of the shaft of the femur.

It has not been felt necessary in any of these cases to deepen the acetabulum by a shelf or any operative measure, as the acetabulum is

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons Cleveland, Ohio, January 13, 1937.

normally of sufficient depth. It might be mentioned, however, at this point that the stability of the reconstructed hip joint would be greatly impaired if the operation were employed in any cases presenting either congenital or acquired deformation of the acetabulum itself.

2. The maintenance of a satisfactory range of movement: The mobility obtained by this type of reconstruction operation is largely due to the fact that the cartilage of the acetabulum is not in any way disturbed at the operation, and care is always taken to keep the upper extremity of the femur protected by a thin fibromuscular layer of tissue. This means that, as there are no raw bony surfaces opposed to the cartilage of the acetabulum, an opportunity is given for free mobility. The active power of the transplanted abductors, reenforced by the flexor and extensor muscles of the hip, permits a wide range of active movement. In abduction particularly, there is no bony block possible, as the whole trochanteric region moves under the upper rim of the acetabulum.

3. The increase in length of an already shortened extremity: The preoperative shortening of these limbs is dependent in great part on the upward riding of the greater trochanter above the superior rim of the acetabulum. In one case the shortening was as much as two and one-half inches, while, after operation, it was reduced to only one-half an inch.

In order to study the average shortening that might follow the placing of the greater trochanter within the acetabulum, a number of adult femora were picked at random in the Anatomical Laboratory at the New York University Medical College. As shown in Figures 1-A and 1-B, the distance between parallel planes passing through the tip of the greater trochanter and the superior surface of the head of the femur ranged between zero and three-

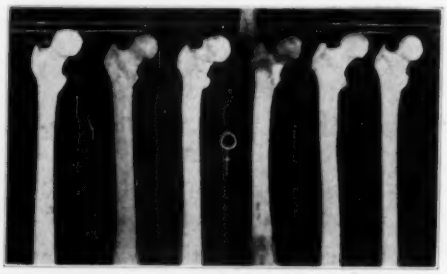

FIG. 1-A

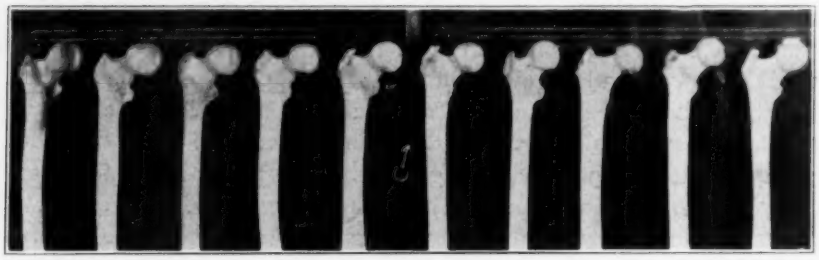

FIG. 1-B

A study of these femora will disclose the slight degree of shortening that follows when the greater trochanter is placed within the acetabulum. As these parallel lines are separated one-half an inch, it may be noted that the affected extremity is usually shortened about one-half an inch less than the sound side by this type of reconstruction operation.

quarters of an inch, the angle of the neck in the female femora being consistently greater than in the male. In none of the femora, however, did this difference exceed three-quarters of an inch. This observation agrees rather closely with the clinical findings noted in the cases operated upon, in that the shortening between the two extremities after operation was never more than three-quarters of an inch and sometimes considerably less. There has been no attempt made to compensate completely for this shortening for at least a year after operation, as it is felt that the slight degree of abduction produced at the hip by the shortening adds to the stability and integrity of the reconstructed joint.

The question of the relief from pain is an important one, as pain is an almost constant complaint in the old ununited cases. It is probably due to several factors, but is largely dependent upon a mechanical one which is relieved by the reconstruction operation. The degree of discomfort after the first few months of operation has varied, but in none of the cases in which an operation was performed has it proved to be a troublesome feature. Baking and massage to the muscles about the hip during the early months of postoperative weight-bearing have been found to be of benefit in some cases; others have not required this treatment.

POSTOPERATIVE CARE

At the end of the operation, a plaster spica is applied, with the limb in from 20 to 25 degrees of abduction and complete extension at the hip. At the end of two weeks, a posterior shell of plaster is removed from the

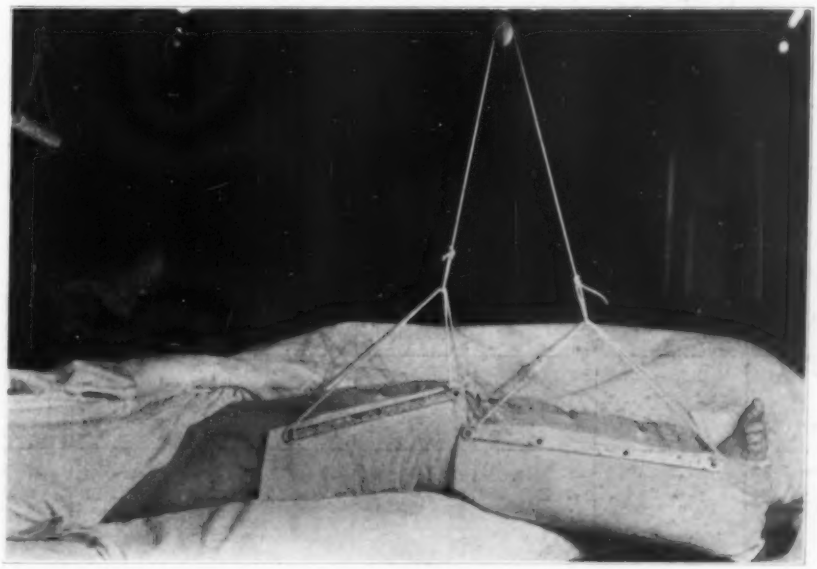

FIG. 2

Showing the limb suspended in a felt sling which may be controlled by pulleys. The patient should be encouraged to move the limb actively in all directions, but especially in that of abduction.

TABLE I

SUMMARY OF FIFTEEN CASES OF OLD UNUNITED FRACTURE OF THE FEMORAL NECK IN WHICH RECONSTRUCTION OPERATIONS WERE PERFORMED

Case No.	Name	Age (*Years*)	Sex	Shortening		Preoperative History	Operation Performed	Complications	Last Report
				Preoperative (*Inches*)	Postoperative (*Inches*)				
1.	Mrs. G. R.	55	Female	1½	¾	Nine months before admission slipped and fractured right hip. Fracture reduced and spica applied. Non-union and absorption of neck resulted.	April 10, 1931	None	July 1937 (over 6 years after operation). Doing housework, walks several miles daily. No pain. AGE*—180; AGF†—90.
2.	Mr. F. M.	70	Male	1	½	Severe pain on weight-bearing. Fractured left hip 6 months before admission. A spica was applied. Non-union resulted.	August 11, 1932	None	December 1926 (over 4 years after operation). Quite active. Stable hip. AGE—180; AGF—100.
3.	Mrs. M. N.	56	Female	1	½	Several months before admission fractured left hip. A spica was applied with subsequent non-union and absorption of neck.	November 10, 1932	None	November 1936 (4 years after operation). At work for past 3½ years. Walks quite well for long distances. AGE—180; AGF—90.
4.	Mrs. A. N.	50	Female	1½	½	Poor general condition. Blood sugar 190 milligrams. Movement of right hip painful. Non-union and neck absorption.	July 20, 1933	Fell 1 year later and dislocated trochanter. Refused further treatment.	January 1936 (over 2 years after operation). Uneventful convalescence. Left hospital 8 weeks after operation, walking well. Does housework and walks with crutch.
5.	Mr. J. B.	68	Male	1½	½	Fractured right hip 5 years before admission. Non-union, severe disability, poor general condition. AGE—160; AGF—140.	August 9, 1933	A psychosis developed 4 weeks later and patient was moved to psychopathic ward.	Six weeks after operation patient was walking about psychopathic ward in a short spica. Transferred to mental institution, and a year later died from natural causes.
6.	Mrs. R. S.	48	Female	1	½	Fractured left hip one year before admission. Non-union, neck absorption, and head necrosis. Very painful hip. AGE—160; AGF—130.	October 18, 1933	None	November 1936 (3 years after operation). Walks well without support. Painless, stable hip. Doing housework. AGE—180; AGF—90.
7.	Mrs. J. G.	45	Female	1	½	Fractured right hip one year before admission. Walking with crutches. Non-union, severe pain on movement.	July 25, 1934	None	August 1937 (3 years after operation). Walks well, does housework. Stable, freely movable hip.

TABLE I (*Continued*)

TABLE I (*Continued*)

8.	Mrs. J. L.	69	Female	2½	½	Fractured right hip 1½ years before admission. Had been in bed ever since accident. Severe deformity.	August 27, 1934	None	August 1936 (2 years after operation). Walks without any support. Stable, painless hip. AGE—180; AGF—100.
9.	Mrs. I. B.	56	Female	1¾	½	Fell and fractured left hip 1½ years before admission. Non-union with neck absorption and head necrosis. Persistent pain.	April 8, 1935	Staphylococcus infection of soft tissues about hip. Discharged 3 months after operation.	June 1937. Walks without cane. No complaint of pain in hip. Presents stable joint with limited motion. AGE—180; AGF—150. Good abduction.
10.	Mrs. R. H.	45	Female	½	½	Fractured left hip 4 months before admission. Spica applied. Non-union. AGE—180; AGF—160.	June 4, 1935	None	November 1936. Walks with cane, does housework. Freely movable hip. AGE—180; AGF—90.
11.	Mrs. L. S.	47	Female	2	¾	Fractured right hip 2 years before admission. Non-union. Walked with crutches.	August 7, 1935	Convalescence uneventful until 19th postoperative day. Patient suddenly became cyanotic and dyspneic. Vomited several times and a few hours later expired. Cause of death undiagnosed. No autopsy permitted, but examination of wound showed no evidence of infection. Temperature after operation never more than 101 degrees.	
12.	Mrs. M. S.	60	Female	1	½	Fractured left hip 3 months before admission. Spica applied. Non-union with neck absorption.	December 11, 1935	None	December 1936. Very active, walks without support, presents painless hip. AGE—180; AGF—90.
13.	Mrs. C. O.	60	Female	½	½	Fractured left hip. Fixation by Smith-Petersen nail 8 weeks later. After 7 months, apparent bony union, and nail removed. X-ray few days later showed frank non-union.	April 1, 1936	None	August 1937. Does housework, presents painless, stable hip. AGE—180; AGF—130.
14.	Mrs. M. McG.	53	Female	1	½	Fell and fractured right hip 6 weeks before admission. No treatment. Non-union with marked neck absorption.	August 26, 1936	None	June 1937. Walks without cane, presents stable, painless joint with limited motion. AGE—180; AGF—150. Good abduction.
15.	Mrs. A. K.	34	Female	1	½	Fractured right hip March 14, 1936. Hip pinned 10 weeks later. Non-union resulted.	October 23, 1936	None	September 1937. Does housework. Presents stable, painless hip with limited motion.

* AGE = Angle of greatest extension.

† AGF = Angle of greatest flexion.

FIG. 3-A

FIG. 3-B

Fig. 3-A: Mrs. G. R. Right hip before operation.

Fig. 3-B: Mrs. G. R. Right hip six years after operation.

foot and leg. This permits the patient to begin early active movement at the knee, and has been a very useful procedure, as in many of the cases there is a good deal of knee stiffness following previous immobilization in plaster. The posterior shell is reapplied when the patient is turned on his back, but is removed several times a day when the patient is turned over, in order that he may exercise the knee while lying on his stomach. At the end of four

weeks, the plaster is completely removed and a well-fitting posterior shell or felt sling (Fig. 2) supports the extremity, and overhead suspension permits active and passive movement at the hip. This is continued for the following two weeks, a pillow being placed between the thighs to prevent adduction during this period. Ordinarily, at the sixth or seventh week after operation, the patient is gotten out of bed and encouraged to walk with crutches or walker. Physiotherapy may or may not be helpful at this stage, but every effort is made to encourage the patient to discard all forms of support as soon as possible. These older people usually need to be encouraged, as many of them are prone to become apprehensive of weight-bearing. This short six-week period of convalescence in bed is felt to be a very important item in the care of the elderly patient, and every attempt is made in the average case to have the patient out of bed and bearing weight six or seven weeks after operation.

COMPLICATIONS

There was one death which occurred as a possible complication from the operation. This patient, aged forty-seven, had a perfectly uneventful convalescence up to the nineteenth postoperative day and then, while being turned by the nurse, she suddenly collapsed and died in a few hours. Examination of the wound showed no evidence of infection, and the cause of death was assigned to a pulmonary embolus. One other patient has since died from natural causes.

In another case a rather persistent infection developed in the soft tissues about the hip which delayed convalescence. The bone was apparently not involved and the end result has been satisfactory. The patient presents a good range of motion and excellent stability, and at present is walking without any support and doing her usual housework.

The only case in which the stability has been impaired is that of a woman, aged fifty, who was operated upon in 1933 and left the hospital at the end of eight weeks, walking with the aid of a crutch. This patient's convalescence was uneventful and she discarded her crutch a few weeks later. During the following year she carried on her housework without any difficulty. At the end of that time, she slipped and fell with the limb markedly adducted. Dislocation of the upper extremity of the femur occurred, but after a few weeks the patient went back to her housework, using a crutch for support. This patient has refused to return to the hospital for roentgenograms or operative interference and is able to be up and about with the use of one crutch. This case, however, is regarded by us as a failure.

END RESULTS

At present thirteen of these fifteen patients are living and have been recently examined. With the exception of the one failure, each of the other twelve presents an excellent range of active and passive movement, stability of the reconstructed hip, and increase in the length of the ex-

Fig. 4-B
Mr. F. M. Left hip four and one-half years after operation.

Fig. 4-A
Mr. F. M. Left hip before operation.

FIG. 5-B
Mrs. J. S. Right hip four years after operation.

FIG. 5-A
Mrs. J. S. Right hip before operation.

tremity. These cases have all had a careful follow-up as shown in Table I. Two of these cases in which this type of reconstruction operation was performed four or more years ago, as well as one case in which the same operation was performed by Dr. Armitage Whitman, are reported in detail. The end results of any proposed surgical procedure are always of importance and value, so that the following histories of these older cases, as well as their roentgenograms, are thought to be of especial interest.

CASE REPORTS

Mrs. G. R., fifty-five years of age, fell in August 1930 and fractured the right hip (Fig. 3-A). Non-union resulted, with shortening of one and one-half inches and complete absorption of the femoral neck. The reconstruction operation described was done on April 10, 1931. At present, six years after operation, the patient is quite active, walks rapidly, and is able to go up and down stairs with ease. She states that she can walk several miles without tiring. The hip is stable with an excellent range of active movement. There is shortening of three-quarters of an inch. A recent roentgenogram is shown in Figure 3-B.

Mr. F. M., seventy years old, fractured his left hip (Fig. 4-A). Non-union resulted, with absorption of the neck and one inch of shortening. The patient was operated upon at Bellevue Hospital on August 11, 1932. A reconstruction operation of the type described was performed. Plaster was removed at the end of four weeks and the patient was allowed to bear weight at the end of six weeks. He was discharged several weeks later to a country convalescent home and presented about 30 degrees of flexion at the hip and a free range of abduction. At present, over four and one-half years after operation, he presents a good range of movement in all directions with only one-half an inch of shortening. The appearance of the reconstructed hip is shown in Figure 4-B.

Mrs. J. S., aged fifty-six, was seen at the Hospital for the Ruptured and Crippled on January 8, 1932. She was unable to walk except with the aid of crutches and complained of severe pain on any movement of the right hip. She had fractured the hip two years previously, non-union had resulted, and at the time of admission to the hospital she presented a frank non-union with absorption of the neck, necrosis of the head, and one and one-half inches of shortening. (See Figure 5-A.) Dr. Armitage Whitman performed the type of reconstruction operation described in this paper, and four weeks later the plaster was removed and overhead swinging traction apparatus was instituted. Seven weeks after operation the patient was discharged from the hospital and her convalescence was uneventful. At present, four years after operation, she is doing her usual housework, is able to walk up and down stairs without the use of a cane, and presents an excellent range of active and passive movement. She has a painless stable reconstructed hip, and a recent roentgenogram is shown in Figure 5-B.

REFERENCE

1. Colonna, P. C.: A New Type of Reconstruction Operation for Old Ununited Fracture of the Neck of the Femur. J. Bone and Joint Surg., XVII, 110, Jan. 1935.

THE SCHANZ OSTEOTOMY FOR FRACTURES OF THE NECK OF THE FEMUR*

BY HERMAN C. SCHUMM, M.D., MILWAUKEE, WISCONSIN

Since 1894, when Kirmisson advised the use of the subtrochanteric osteotomy in "certain cases of congenital dislocation of the hip", there have been several waves of enthusiasm in regard to the use of this method or its modifications for various conditions affecting the stability of the hip joint. Von Baeyer and Lorenz with their bifurcation operations and Schanz with his controlled subtrochanteric osteotomy are among the more important advocates of the use of this method, especially in cases of ununited fracture of the neck of the femur. Brackett, in 1912, called attention to the importance of controlling the fragments following osteotomy of the upper end of the femur. It remained for Schanz to correlate these findings and to present the mechanical principles and the technique of the operation that now bears his name.

The keystone of his ideas on the mechanics underlying the treatment of fractures of the neck of the femur is best given in his statement: "Through the angulation of the neck, the fracture site is placed below the head and the body weight no longer pushes the head downward past the fracture surface but directly against it. This provides more favorable weight-bearing relations and may even lead to late bony union." Pauwels, a former assistant of Schanz, has given us a more scientific and elaborate explanation of this principle.

The indications for this operation are: (1) disability due to instability of the hip, which may be accompanied by varying degrees of pain and fatigue, and (2) those cases of delayed union or non-union with coxa-vara deformity in which there is still a chance to effect a union by relieving the shearing force present.

In studying our cases for operation, we have divided them into two classes: (1) cases in which an insidiously developing coxa vara indicates a prospective non-union, and (2) cases of definite non-union with absorption of the neck, in which there is a marked upward riding of the shaft, so that the fracture surfaces have slid by one another. This classification is a guide to the site for osteotomy. In the first group the osteotomy is placed just above or as near to the lesser trochanter as possible and is often spoken of as the high osteotomy (Figs. 2 and 3); whereas in the second it is placed several centimeters lower and is called the low osteotomy (Fig. 8). This low osteotomy is the true Schanz osteotomy. As Schanz pointed out, an anteroposterior roentgenogram, taken with the affected leg in maximal adduction, is of importance in determining the degree of angulation desired and, in the low osteotomy, is of help in definitely

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Cleveland, Ohio, January 13, 1937.

locating the site. The angle corresponds to that formed by the upper portion of the adducted shaft and the long axis of the body. In the low osteotomy, this angle varies between 35 and 60 degrees. In the high osteotomy, the angle should be somewhat greater, varying between 45 and 70 degrees. The site for the low osteotomy is at the point of closest approximation of the shadow of the shaft to the pelvic rim, which is usually at the distal end of the tuber ischii.

We do not feel that a lateral view of the hip gives any additional help in determining the site or the degree of angulation.

OPERATIVE TECHNIQUE

The technique used by us is essentially that of Schanz. With the patient on the fracture table and the affected hip elevated with a sandbag, a lateral incision is made, centering over the elected site for osteotomy. With the femur exposed, holes are drilled through the shaft into which the special Schanz screws are placed. One hole is drilled above and another below the site of the proposed osteotomy, leaving a minimal working space of at least five centimeters between the holes. Instead of drilling at right angles to the shaft, as Schanz suggests, we prefer Riedel's modification of drilling obliquely at the desired angles, so that, when the screws are inserted and then brought parallel, the fragments are in the desired position. A protractor, or a piece of stiff tin foil cut to the desired angles, is used as a guide for the drill holes. It is preferable that the angle of the hole in the upper fragment be approximately one-third of the total angle desired and that the angle of the hole in the lower fragment be the remainder.

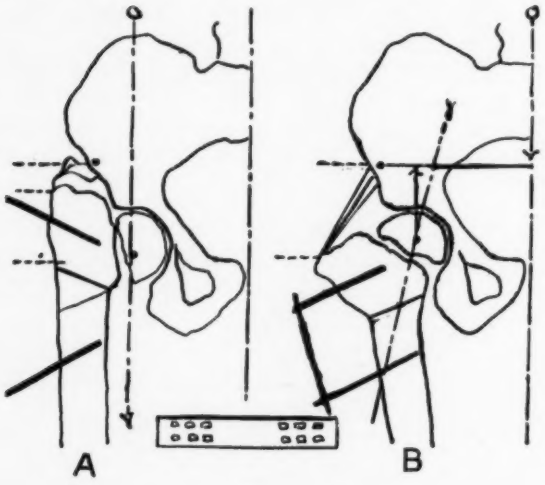

FIG. 1

A: The oblique insertion of screws (Riedel) allows greater working space than when the screws are introduced perpendicularly to the shaft, as in a true Schanz osteotomy. Note relaxation of muscles attaching to greater trochanter due to upward riding. Inefficiency of these muscles is also due to loss of lever action.

B: Shows screws parallel after angulation of femur and securely fixed by use of Riedel plate. Note effect on musculature following osteotomy.

After the screws have been inserted, and not before, the femur is divided. In the high osteotomy, a wedged osteotomy with the base on the lateral aspect is desirable, but in the low we have found a modified transverse osteotomy to be more efficient. The modification consists of

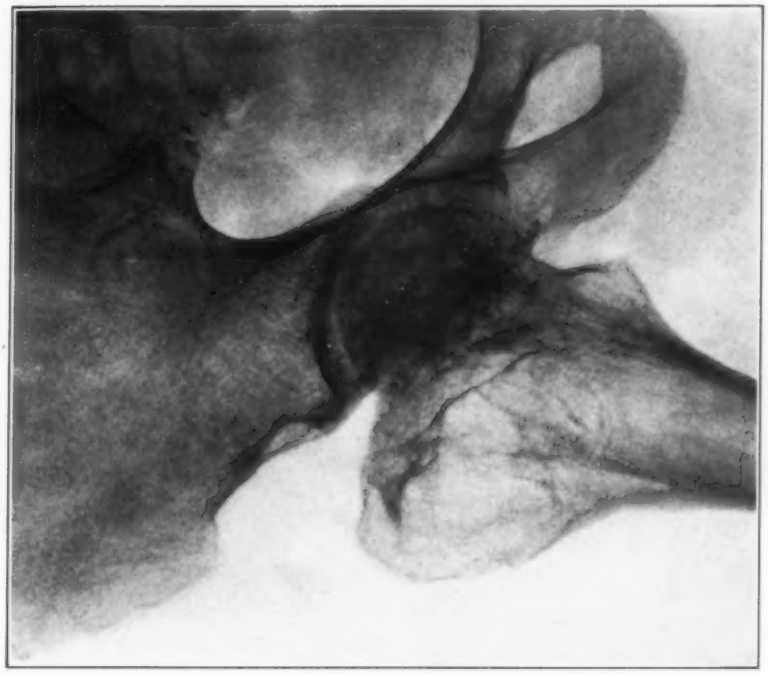

FIG. 3

Same patient as in Fig. 2 after high Schanz osteotomy, showing solid bony union. Result excellent. Patient walks without limp. No pain in hip. Occasional pain in back and knee.

FIG. 2

Fracture of the neck of the femur with non-union two years after fracture.

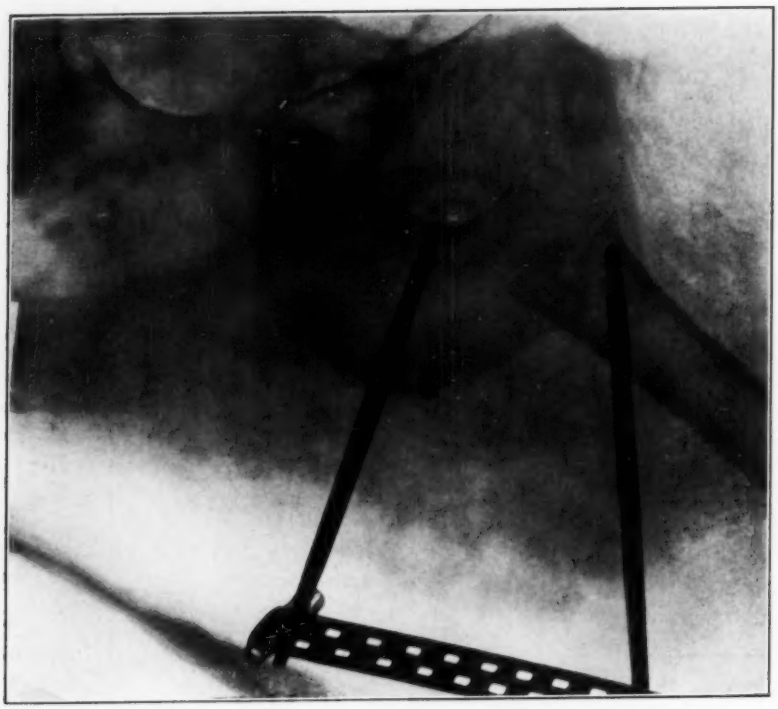

FIG. 5

Same patient as in Fig. 4, showing position of fracture following a low Schanz osteotomy, with Schanz screws and Riedel plate in place.

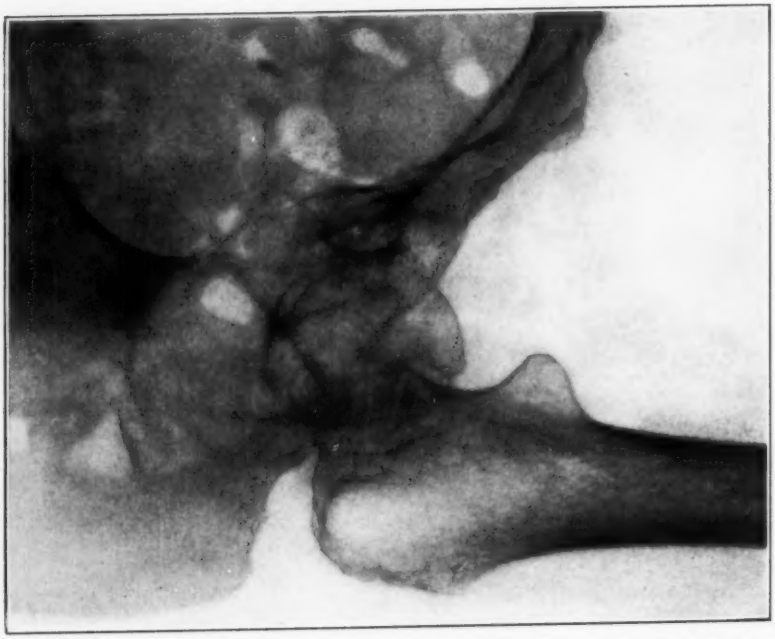

FIG. 4

Ununited fracture of the femur four months following fracture.

leaving a projecting tongue extending upward on the lateral aspect of the lower fragment, which engages in the medullary cavity of the upper fragment, thus assisting to hold the fragments in position. By dividing the medial half of the shaft first, one can help prevent a splintering of the shaft, which is occasionally experienced when doing osteotomies on older people. The wound is then closed in layers, the screw ends projecting from the wound. To hold the desired angle, the screw ends are securely fixed by attaching a Riedel plate. (See Figures 4, 5, and 6.) A large, plaster spica is applied, including the well leg down to the knee.

FIG. 6

Same patient as in Figs. 4 and 5. Roentgenogram one year following Schanz osteotomy, showing solid bony union of ununited fracture. Result excellent. Patient climbs stairs and laces shoes without difficulty.

AFTER-TREATMENT

As soon as the patient is comfortable and the cast has thoroughly dried, a window is cut in the cast over the knee to permit passive motion of the patella and gentle massage of the knee. At the end of six weeks, through a second window exposing the operative wound, the stitches and screws are removed. This can be done with but little pain to the patient. At the end of the first postoperative week, a check-up roentgenogram is taken. At the end of the eighth week, the cast is removed and another check-up roentgenogram is taken. If there is not sufficient callus present, a light splint is applied, holding the hip in abduction.

For the first week or two following removal of the cast, the patient is given sling-suspension exercises in bed and baths in the Hubbard tub. At the end of the second week, an additional check-up roentgenogram is taken and, if the condition appears favorable, the patient is permitted to be up with crutches.

It is claimed that the advantages of this method are: (1) safety and simplicity, and (2) increased stability with a corresponding lessening of, or

FIG. 7

Ununited fracture of the neck of the femur. Roentgenogram showing position at time of operation one year following fracture.

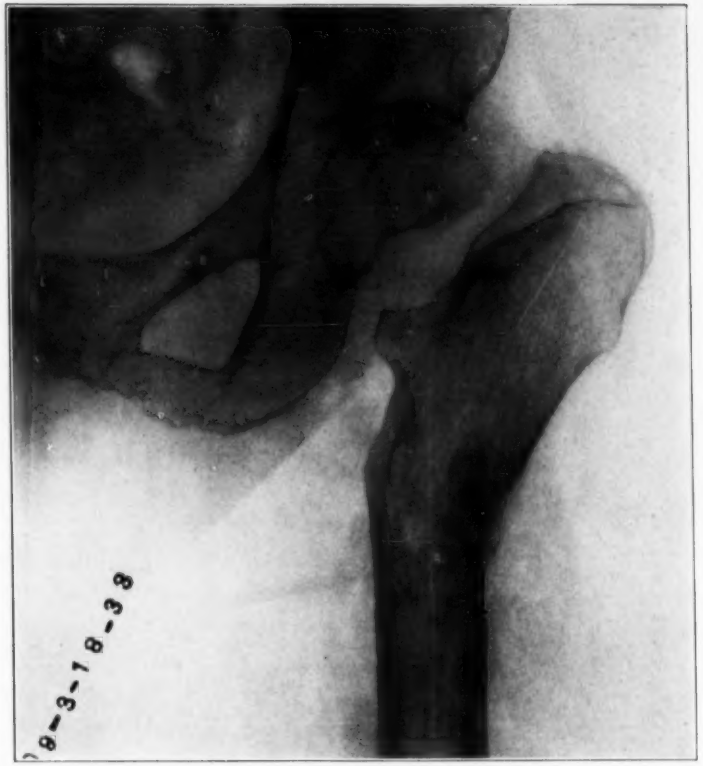

FIG. 8

Same patient as in Fig. 7 after low Schanz osteotomy. Result very satisfactory. Patient walks without pain or fatigue, although with a moderate limp.

entire freedom from, pain and fatigue. The increased stability is considered due to several factors: namely, (1) improved leverage conditions favoring the gluteii; (2) improved efficiency of the gluteii themselves when they are put under tension by the depression of the trochanters; and (3) contact of the angulated upper fragment against the pelvic wall. (See Figures 1,*A*, 1,*B*, 7, and 8.)

CLINICAL FINDINGS

Our series consists of thirteen cases of ununited fracture of the neck of the femur, in which operations were performed by the late Dr. Frederick J. Gaenslen, by Dr. Walter P. Blount, or by the author, as well as an additional fifteen cases in which the Schanz osteotomy was performed for other unstable conditions such as old congenital dislocation of the hip, making a total of twenty-eight cases. In the series of hip fractures, four of the osteotomies were of the high type and nine were of the low. The ages of these patients ranged between twenty-two and seventy-nine years, the average age being fifty-five years.

In addition to the ordinary hazards of age, the following preoperative complications were found: serious cardiac involvement in two cases; pernicious anaemia in one case; generalized fibrocystic disease in one case; a definite mental depression in one case; marked osteo-arthritis of the hips in one case; and osteo-arthritis of the hip and knee of the affected side in one case.

There have been no deaths in this series, nor were there any deaths in the series of fifteen cases in which operations were performed for conditions other than fracture of the femoral neck. In the combined series, there was but one case of shock sufficient to cause us even the slightest worry—a surprisingly low number, considering the ages and preoperative complications.

In only one case, that in which a high osteotomy was performed, did the limp completely disappear. In six cases, the stability was definitely improved and the limp was but slight. As regards motion, flexion was limited in only two cases, in both of which an osteotomy of the high type was performed. The other motions were more or less limited in all cases. Three of the patients still complain of definite pain in the leg, either in the region of the hip itself or in the thigh. One of them has a marked osteo-arthritis of both hip and knee with definite limitation of motion in the knee, while another complains of pain in all of her joints, but especially in the hip, although no definite pathology has been found to account for the pain. This patient can sit without difficulty and walks with only a slight limp without support, although she prefers to use a crutch. The third patient had a very definitely delayed union at the site of the Schanz osteotomy, with a resulting loss in angulation. When she was finally permitted to be up and about, she fell, fracturing the other hip. Superimposed on this is a bad heart that has necessitated bed treatment. The remaining patients do a partial or a full day's work, although toward the

end of the day most of them complain of a sense of fatigue in the operated hip. This sense of fatigue lessens after the first year.

The three patients with pain do not admit any improvement following the operation, while the others admit, or in most cases have volunteered the information, that they have been definitely benefited. Nine of the patients walk without support in the house, although all but two use a cane, or a cane and a crutch, when they go out on the street. Five patients state that they are able to walk up and down stairs without difficulty if they can put their hands on a rail to steady themselves. Two others can walk up and down stairs, but they have to go somewhat slowly and use a cane for support. Three patients have not stated their ability along this line. The remaining three, for one reason or another, have not tried.

Genu valgum is a condition that should be watched for, especially preoperatively. Those cases with more than 7 degrees of genu valgum deserve special consideration. The valgus deformity is apt to become much more pronounced postoperatively, especially following the low operation, and will be a factor in postoperative pain. The patient should be advised of this possibility. In the more marked cases, we now consider the question of correcting the deformity by a supracondylar osteotomy at the time we do the Schanz osteotomy, or we plan on doing it at a later date. Four of our patients have had an accompanying or delayed supracondylar osteotomy. In one case there was a slight delay and in another a very definite delay in union at the site of the Schanz osteotomy, but there has been no case of permanent non-union. Based on the symptoms and physical findings, the results in this series were considered good in seven cases, fair in three cases, and poor in three cases. The unsatisfactory results in the last three we attribute to poor or faulty judgment either in selection of the patient or of the site of operation.

CONCLUSIONS

1. The Schanz osteotomy is as simple and as shock-proof an operation as we have found, for the conditions for which it has been used.

2. It results in a definite increase in stability of the hip, without seriously interfering with the motions necessary in sitting, mounting stairs, or in dressing.

3. Because of increased stability, there is definite relief from pain and fatigue.

4. The most important complications are increasing genu valgum, delayed union or non-union at the site of osteotomy, and loss of angle at the site of osteotomy.

REFERENCES

v. BAEYER: Operative Behandlung von nicht reponierbaren angeborenen Hüftverrenkungen. Münchener med. Wchnschr., LXV, II. Hälfte, 1216, 1918.

Die Bifurkation nach Baeyer-Lorenz. Ein Protest. Ztschr. f. orthop. Chir., XLIV, 591, 1924.

BRACKETT, E. G.: A Study of the Different Approaches to the Hip-Joint, with Special Reference to the Operations for Curved Trochanteric Osteotomy and for Arthrodesis. Boston Med. and Surg. J., CLXVI, 235, 1912.

CAMITZ, H.: Die Pseudarthrosen (nebst wahrscheinlichen Vorstadien) nach medialen Frakturen des Collum Femoris und deren Behandlung. Acta Chir. Scandinavica, LXVIII, Supplementum XIX, 1931.

GAENSLEN, F. J.: The Schanz Subtrochanteric Osteotomy for Irreducible Dislocation of the Hip. J. Bone and Joint Surg., XVII, 76, Jan. 1935.

Fracture of the Neck of the Femur. Sir Robert Jones Lecture in Orthopedic Surgery. J. Am. Med. Assn., CVII, 105, 1936.

KIRMISSON, E.: De l'ostéotomie sous-trochantérienne appliquée à certains cas de luxation congénitale de la hanche. (Flexion de la cuisse avec adduction considérable). Rev. d'Orthop., V, 137, 1894.

LORENZ, ADOLF: Ueber die Behandlung der irreponiblen angeborenen Hüftluxationen und der Schenkelhalspseudarthrosen mittels Gabelung (Bifurkation des oberen Femurendes). Wiener klin. Wchnschr., XXXII, 997, 1919.

PAUWELS, FRIEDRICH: Der Schenkelhalsbruch; ein mechanisches Problem. S. 6. Stuttgart, Ferdinand Enke, 1935.

RIEDEL, GUSTAV: Haltelochplatte für Schanz'sche Schrauben. Zentralbl. f. Chir., LVII, 84, 1930.

SCHANZ, A.: Zur Behandlung der Schenkelhalsbrüche. Arch. f. klin. Chir., LXXXIII, 336, 1907.

Ueber die nach Schenkelhalsbrüchen zurückbleibenden Gehstörungen. Deutsche med. Wchnschr., LI, 730, 1925.

Praktische Orthopädie. S. 303. Berlin, Julius Springer, 1928.

THE VALUE OF EARLY WEIGHT-BEARING IN THE TREATMENT OF FRACTURES OF THE NECK OF THE FEMUR

With a Report of Twenty-Four Cases *

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In the management of fractures of the neck of the femur there has always been considerable uncertainty about the ultimate healing and function. This has arisen from two factors: (1) Many fractures at the hip occur in old people in whom the nutrition of the injured tissues and their reparative processes are admittedly very poor; (2) experience has demonstrated that in a large proportion of cases the fractures actually do not heal, and severe disability ensues. These facts have led in general to two types of treatment,—namely, prolonged immobilization and rest in bed over a period of many months, and the utilization by operative intervention of some foreign material, like nails or wires, to contact and appose the fragments, in the hope that their close apposition will favor and assure union.

Several years ago it occurred to me that, if weight-bearing and friction stimulate callus formation in an ancient non-union of a fractured tibia, they might serve the same purpose in fractures at the hip. Consequently, I determined to anticipate non-union in every fracture at the hip, and to institute weight-bearing early, almost immediately after the reduction, hoping thereby to prevent a large percentage of non-unions. However, if the patient is to bear weight on the injured member, two conditions must be obtained,—satisfactory reduction and adequate immobilization.

Many years ago Royal Whitman taught us the abduction treatment for fractures at the hip. This method provided the opportunity for apposing the fragments by traction, inward rotation, and abduction. Thus the shortening was overcome, the fragments were brought into contact, and the corrected attitude of the limb was maintained by a long plaster-of-Paris spica bandage. Equality in length of the injured and well limbs and a roentgenogram showing the fragments in apposition were the criteria of reduction. The principles of the reduction and the immobilization were correct and remain so. Some of the details of the treatment, however, have recently been advantageously modified.

It had been the custom, in order to avoid pressure sores, to apply stockinet and many layers of sheet cotton over the skin under the plaster spica. This did make a comfortable dressing, but, as the cotton became compressed, it was found that there was too much room between the skin and the plaster, reducing the effectiveness of the immobilization. On a number of occasions, slipping of the fragments actually took place in the

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plaster spica. This can be prevented by the Leadbetter technique which I have used in all transcervical fractures. In order to prevent any possible slipping of the fragments in the plaster, I take the extra and very important precaution of placing one or more reverses around the groin and the buttock. These are carefully molded about the descending ramus of the pubic bone and the ischium. This detail maintains the required length of the limb between the sole of the foot and the pelvis, prevents displacement of the fragments, and materially enhances the protection afforded by the splint. A postoperative roentgenogram is made directly after the plaster dressing is finished, in order to be certain that the reduction is being maintained in the plaster spica. In the cases of intertrochanteric fractures, the patient is placed on a Hawley table with the padded perineal bar pressing against the symphysis pubis. The well limb is supported in moderate abduction. By traction on and inward rotation and abduction of the injured limb, the deformity is corrected and a plaster-of-Paris spica bandage is applied in exactly the same manner as for a transcervical fracture. In comminuted intertrochanteric and subtrochanteric fractures of the femur the deformity is likewise reduced by manipulation, preferably with the aid of the fluoroscope to be sure that the general longitudinal alignment is satisfactory, and a plaster spica is applied in the manner indicated. If the reduction, as shown by the postoperative roentgenogram, is satisfactory, we may assume that the splint will maintain it and will permit the movement of the patient without fear of slipping of the fragments.

The patient is allowed to remain in bed for several days to get used to the plaster support. On the third to the seventh day after the reduction the patient is taken out of bed and allowed to stand up for a few minutes. This procedure is repeated on each of several days, during which time the patient rapidly learns that the upright position in the plaster is not only possible but comfortable. He is provided with crutches and after an additional period of from one to four or five days, depending upon his ambition, he learns to walk. By the tenth to the fourteenth day after the reduction the patient is able to walk about his room, and may be discharged from the hospital. Thereafter the patient gets out of bed at least once a day, and often two or three times a day, remaining standing or walking and *bearing weight* on the injured limb for fifteen to thirty minutes. It is noteworthy that, if the plaster spica has been thoroughly molded to the hip, pain is immediately and permanently relieved.

At the end of two months the patient returns to the hospital, the plaster is removed, and another roentgenogram is taken. If this shows bony union, as it has so far in every one of my series of cases except two in which the treatment had to be interrupted—in one on account of an acute cholecystitis and in the other because of the onset of a maniacal mental derangement—a short spica is applied and the patient is again discharged to home care, with instructions to walk for increasing periods several times each day, using crutches but *bearing weight* on the injured limb. The short spica is left on for a month to six weeks, and is then replaced by a

canvas corset spica for another month, after which no dressing is required. The second or short spica extends at first to the middle of the leg. Gradually this plaster is cut away, so that in a fortnight it extends only to the knee, allowing a gradual return of motion in this joint.

THE EFFECT OF EARLY WEIGHT-BEARING

1. On the patient's morale: We have up to now been compelled to announce to a patient with a fractured hip that he will be confined to bed for at least three months and very likely six months. This, naturally has been very depressing news not only to the patient but to the family. In many instances this period has been prolonged to nine months or even a year. With the employment of the system of treatment herein described, within a week the patient is out of bed, standing one or more times a day, and within two weeks or less he is walking across the room. This has a comforting and stimulating effect on the patient who appreciates that not only is he not doomed to prolonged and chronic invalidism but he is actually on the road to recovery.

2. On the nursing care of the patient: Through the teachings of Royal Whitman, we have for many years known how to care for a patient confined because of a fractured hip. When the plaster spica is properly applied, the patient is free from pain and can be turned on his face several times a day for cleansing of the skin. Thus bed sores are avoided. The change of posture also prevents hypostatic pulmonary congestion. Getting the patient out of bed affords even better opportunity to keep the skin intact and clean. The more radical change of posture improves breathing and even more certainly prevents pulmonary stasis. In addition, the repeated use of the blow bottles assures thorough aeration of the lungs. Incidentally it should be emphasized that, when a long plaster spica has been firmly applied, one nurse or an attendant can easily handle the patient, turn him from one position to another, and get him out of bed for walking. My assistant, Dr. Max Rabinowitz, has treated ten cases of fracture of the hip in the last two years by the ambulatory method. In many of them there was no need for professional nursing care, as he was able to instruct a member of the family in the essentials of nursing, thus reducing the economic burden which has always been a heavy one in the treatment of a fracture at the hip.

3. On the position and circulation of the fractured fragments: It is well known that in a truly impacted fracture of the neck of the femur healing by bony union progresses rapidly. I believe that weight-bearing causes an impaction of the fragments. With each step the fragments are forced into more intimate contact until they are locked. This secondary impaction not only secures the reduction but assures thorough vascularization of the fractured area through the blood supply from the distal neck fragment and the posterior portion of the joint capsule which, according to autopsy experience, is rarely torn. That there is actually an increased degree of contact or an impaction may be deduced from the observation that in

TABLE I

ANALYSIS OF TWENTY-FOUR CASES OF FRACTURE AT THE HIP TREATED BY REDUCTION, IMMOBILIZATION, AND EARLY WEIGHT-BEARING

Case No.	Name	Sex	Age (*Years*)	Duration of Fracture at Time of Reduction	General Condition of Patient	Type of Fracture	Weight-Bearing Begun	Result	Remarks
1.	M. G.	Female	61	4 days	Good	Trans-cervical	4th day	Bony union	Firm healing in 3 months. At end of 5½ months the patient traveled long distances unaided.
2.	W. B.	Male	55	4 days	Good	Trans-cervical	4th day	Bony union	At end of 3 months walked 2 flights of steps without assistance.
3.	B. C.	Male	44	3 weeks	Good	Trans-cervical	3rd day	Bony union	Healed in 2 months. Patient returned to former work at end of 6 months.
4.	M. M.	Male	80		Poor	Trans-cervical	3rd day	Bony union	Healed in 2 months. Functional result is unusually good.
5.	M. R.	Male	62	Several days	Good	Trans-cervical	9th day. Hernia prevented walking.	Bony union	Had large bilateral inguinal hernia, preventing walking. Had apparatus for tapping limb to imitate walking. Healed in 2 months.
6.	S. H.	Male	65	9 days		Trans-cervical	8th day	Bony union	Healed in 2 months.
7.	M. H.	Female	88	3 weeks	Poor	Trans-cervical	7th day	Bony union	On admission, patient had severe pain, rales in chest, and sacral decubitus.
8.	M. B.	Male	64	1 day	Very poor	Trans-cervical	4th day	Bony union	Healed in 3 months.

TABLE I—(*Continued*)

Case No.	Name	Sex	Age (*Years*)	Duration of Fracture at Time of Reduction	General Condition of Patient	Type of Fracture	Weight-Bearing Begun	Result	Remarks
9.	J. K.	Female	65	2 days	Good	Trans-cervical		Bony union	Although the alignment was not perfect, there was enough end-to-end contact to insure union.
10.	L. R.	Female	66	1 day	Good	Trans-cervical	5th day	Bony union	Although she stood up on 5th day, she did not begin to walk until 3rd week. Has walked considerably since then.
11.	P. M.	Female	67	Several days	Poor	Trans-cervical		Non-union	Patient had had hemiplegia. Had acute mental derangement. Treatment interrupted.
12.	E. N.	Female	55	Several days	Good	Trans-cervical		Non-union	Patient developed acute cholecystitis, necessitating removal of large part of plaster and interruption of treatment.
13.	I. S.	Male	60	1 day	Fair	Inter-trochanteric	4th day	Bony union	Reduction under local anaesthesia. Very free motion at hip.
14.	E. P.	Female	95	5 days	Poor	Intertrochanteric, extensive comminution	10th day	Bony union	Had fracture of right elbow and extensive contusion of opposite lower limb. Fracture of right clavicle. Extensive laceration of right buttock and sacral area. Hip healed in 3 months.
15.	I. S.	Male	10	5 days	Good	Intertrochanteric	10th day	Bony union	Solid union in 2 months.

16.	B. S.	Female	60	4 weeks	Good	Intertrochanteric		Bony union	Shaft of femur fractured during manipulation.
17.	A. B.	Female	71	1 day	Good	Intertrochanteric	4th day	Bony union	Was out of bed on an average of 6 hours each day.
18.	R. P.	Female	62	5 days	Poor	Intertrochanteric	2nd day	Bony union	Healed in 2 months. Slight coxa vara.
19.	J. R.	Male	45	3 days	Fair	Intertrochanteric, comminuted	10th day	Bony union	Delay in getting patient out of bed because of injury to chest muscles and possible injury to head.
20.	L. L.	Female	69	2 days		Intertrochanteric	Stood 5th day, walked 3rd week	Bony union	Local anaesthesia. Some coxa vara.
21.	D. L.	Female	60	13 days	Very poor	Intertrochanteric	3rd week	Bony union	Standing and walking delayed because of diabetes, ketosis, and fibrillating heart. It was especially important for this patient to get out of bed, otherwise she might have developed bed sores and sepsis. Walked 1 month after reduction.
22.	M. G.	Female	60	2 days	Very poor	Intertrochanteric, comminuted	3rd day	Bony union	Patient had diabetes and myocarditis. Some coxa vara and separation of lesser trochanter resulted.
23.	B. F.	Female	66	1 day	Very poor	Intertrochanteric	3rd day	Bony union	General anaesthetic. Had had hemiplegia. Had been getting about holding on to objects.
24.	E. W.	Female	75	1 day	Very poor	Intertrochanteric		Bony union	Severe myocarditis, valvular disease, arteriosclerosis.

every case of a fracture through the neck of the femur in my series the late roentgenograms show that the femoral neck is shorter than it was directly after the reduction. This shortening has taken place without any appreciable lateral displacement of the fragments and is, therefore, the result of more intimate interlocking. The blood supply to the femoral head has, in my cases, been adequate, as seems evident from the fact that the density of the head, neck, and shaft of the femur has remained uniform,—that is, there has been a complete absence of any aseptic necrosis of the head seen so frequently in cases of non-union. As the blood supply from the ligamentum teres has only a limited distribution, the femoral head must, in my cases, have derived most of its nutrition through the blood vessels which enter it from the distal neck fragment and the joint capsule.

4. On healing of the fracture: In every one of my cases in which the treatment was carried on without interruption—in all but two patients—the healing took place as rapidly as elsewhere in the femur. There was bony union at the end of two months. I maintained immobilization by a short spica for another six weeks, probably through ultraconservatism rather than because of any urgent need for it. A number of my patients between sixty and seventy years of age were able to walk several flights of steps at the end of the fourth month. One patient (Case 1) went shopping alone in New York for an entire day five and one-half months after the occurrence of the fracture.

The average age of the patients with transcervical fractures was sixty-

TABLE II

REVIEW OF TWELVE CASES OF INTERTROCHANTERIC FRACTURE WITH REFERENCE TO ULTIMATE ANGLE BETWEEN NECK AND SHAFT OF FEMUR

Case No.	Name	Before Reduction (*Degrees*)	After Reduction (*Degrees*)	Ultimate Angle (*Degrees*)
13.	I. S.	130	150	134
14.	E. P.	115		130
15.	I. S.	145		145
16.	B. S.	120		110
17.	A. B.	115	150	150
18.	R. P.	110	150	110
19.	J. R.	120		115
20.	L. L.	120	130	115
21.	D. L.	115	135	115
22.	M. G.	133	123	105
23.	B. F.	115	130	130
24.	E. W.	130		130

four years plus, the youngest patient being forty-four, and the oldest eighty-eight; the average age of those with intertrochanteric fractures was sixty-one, the youngest patient being ten and the oldest ninety-five years. (See Table I.) The system of treatment herein described seems equally applicable at all ages. With very few exceptions, the general condition of most of my patients on admission to the hospital was very poor. In several instances the medical consultants advised me to let the patients die in peace. Had I failed to apply treatment, it is likely that many of the patients in this series would have died from pneumonia, exhaustion, bed sores with secondary sepsis, or some similar complication, for many of them had advanced degrees of diabetes, arteriosclerosis, myocarditis, or nephritis. Yet none of these grave systemic lesions interfered with the healing of the fracture.

In the use of early weight-bearing in the intertrochanteric and subtrochanteric fractures, the chief advantages are: (1) The patient is more comfortable than if he were continuously in bed; (2) the nursing care is simplified; and (3) pulmonary congestion is avoided. Much interest centers about the fact that in intertrochanteric fractures, although union occurs in practically 100 per cent. of the cases, there is often left a coxa vara which causes a limp and a variable disability. In six, or 50 per cent. of the twelve cases of intertrochanteric fracture herein reported (Table II), there was a residual mild or moderate coxa vara. In six of seven cases in which measurements were made in the immediate postoperative roentgenogram, the angle between the neck and the shaft was normal or better than normal, the average being 120 degrees; ultimately, however, this angle was maintained in only two cases. A further study shows that the angle was maintained in the original plaster, but was lost in the second plaster applied at the end of two months. In all but one instance, the second plasters were not applied by me and were much too loose, allowing a certain amount of give at the fracture line. I, therefore, conclude that to avoid an ultimate coxa vara in intertrochanteric fractures it is necessary to leave on the original spica for at least three months, or until there is solidification of the union. Should it be necessary to reapply a plaster spica sooner, the dressing should be accurately molded about the hip to maintain abduction and the required angle between the neck and shaft of the femur.

ANAESTHESIA IN THE AGED

Several of my colleagues have used novocain locally for the reduction of the fracture and so have eliminated the potential ill effects of a general anaesthetic. I prefer a general anaesthetic because it affords greater relaxation and better opportunity for accurate and rapid reduction. My average time for reduction of the fracture and application of a plaster spica is fifteen minutes. With a thoroughly organized team of assistants, ten minutes is probably enough. Any patient who cannot tolerate a fifteen-minute light anaesthesia of ethylene or of avertin, nitrous oxide, and

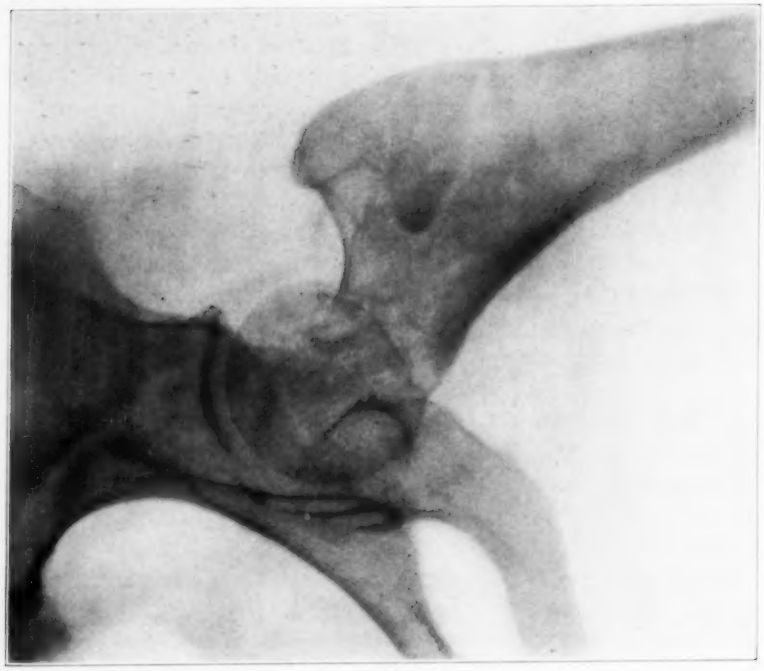

FIG. 2

Case 1. Directly after reduction. Note the alignment of the fragments and the length of the femoral neck. There is moderate coxa valga.

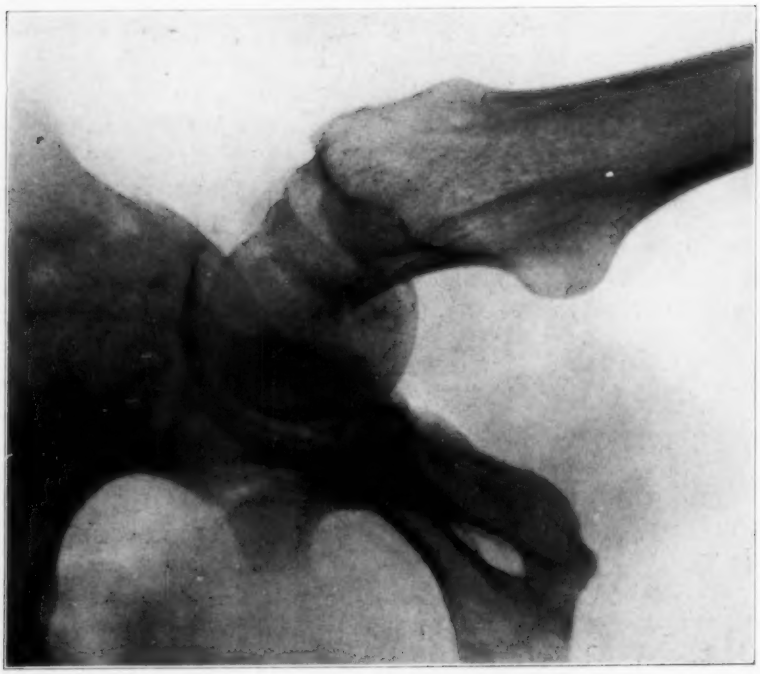

FIG. 1

Case 1. Transcervical fracture of the left hip.

oxygen will probably not survive at all. As a matter of fact, of the many patients with fractured hips whom I have treated in the last twenty-five years, not one has died either under anaesthesia or because of it.

FIG. 3

Case 1. Patient walking freely with crutches every day.

REPORT OF ILLUSTRATIVE CASES

CASE 1. Mrs. M. G., sixty-one years old, was admitted to the Hospital for Joint Diseases on February 15, 1936, four days after injuring the left hip. She had severe pain in the left hip and total disability. She was markedly depressed, feeling that she was going to remain totally incapacitated and a burden to herself and to her family. The clinical and roentgenographic examinations (Fig. 1) showed a transcervical fracture. The fracture was reduced under a general anaesthetic. The postoperative roentgenogram (Fig. 2) showed an excellent alignment of the fragments. The pain was immediately relieved. The patient was taken out of bed on the fourth day and soon was walking about the hospital corridors with the aid of crutches (Fig. 3). Her depression disappeared and she became cheerful.

The long plaster spica was removed after two months, at which time clinical and roentgenographic evidence indicated healing of the fracture. A short spica was applied and walking was continued. The short spica was removed after one month. There was not only firm union clinically, but a roentgenogram (Fig. 4) showed osseous union of the fragments and bony lamellae, extending from the head into the neck. This roentgenogram shows

FIG. 4

Case 1. Three months after reduction. The fracture has healed. The neck is shorter than it was directly after reduction (Fig. 2) because of secondary impaction of fragments as a result of weight-bearing.

FIG. 5

Case 10. Transcervical fracture of the right hip.

the shortening of the neck due to secondary impaction resulting from weight-bearing. The density of the head is similar to that of the neck, indicating adequate vascularization across the fracture line.

The patient was provided with a laced canvas spica and a cane was substituted for the crutches. Five and one-half months after the injury she went shopping alone all day long, and, as she expressed it, walked "plenty". I examined her in October and found that not only was she quite independent of all assistance but that she had a more than adequate range of motion in the hip. She sat down in an ordinary chair and got up with ease. At the hip, extension was complete, and there was flexion to 140 degrees. She had 35 degrees of abduction and 25 degrees of adduction. Rotation was possible through half of the normal range. The lower limbs were of equal length.

FIG. 6

CASE 10. L. R., female, sixty-six years old, sustained a transcervical fracture of the right hip (Fig. 5) on August 22, 1936. I saw her on the following day. The fracture was reduced and an ambulatory plaster spica was applied. The postoperative roentgenogram (Fig. 6) showed an excellent reduction. It is interesting to see the very thorough realignment in spite of the fact that the Leadbetter heel-palm test was negative after three

FIG. 6.

Case 10. After reduction, showing excellent alignment and contact of the fragments. Note the comparatively long femoral neck.

attempts at reduction. This patient was unusually timid. Hence she did not stand up until the fifth or sixth postoperative day and did not really begin to walk until the third week. She then walked several times a day, usually going several times across her bedroom floor which was unusually large.

Nine weeks after the fracture, on October 26, 1936, clinical and roentgenographic examinations (Fig. 7) showed good alignment and bony union. The neck was moderately shortened, demonstrating the secondary impaction of the head onto the neck, a very wholesome effect. On December 15, 1936, sixteen weeks after the reduction, there was solid bony union. The patient walks with the aid of a cane.

FIG. 7

Case 10. Two months after reduction. The fracture has healed. The neck is shortened through secondary impaction of the fragments.

CASE 17. A. B., female, seventy-one years old, was injured on August 3, 1936. She sustained an intertrochanteric fracture with marked separation of the fragments (Fig. 8). She was admitted to the Hospital for Joint Diseases on the following day. The fracture was reduced and an ambulatory plaster spica was applied. The postoperative roentgenogram showed excellent alignment of the fragments. The patient was taken out of bed on the fourth day and within a few days thereafter she was able to stand and to walk comfortably with crutches. She was then taken to her daughter's home.

Two months later the spica was removed and the clinical and roentgenographic examinations (Fig.

FIG. 8

Case 17. Intertrochanteric fracture of the left hip. Note the wide separation of the fragments.

FIG. 9

Case 17. Two months after reduction. The fracture has healed, and the alignment of the fragments is satisfactory.

9) showed healing of the fracture. A short plaster spica was applied, and the patient left for her own home in California.

END RESULTS

This paper is based on an experience with twenty-four cases of fracture of the neck of the femur,—twelve transcervical and twelve intertrochanteric. Bony union was obtained in all but two cases in which an intercurrent illness interrupted and terminated the treatment within the first two weeks after the reduction. Solid bony union was obtained in twenty-two of the twenty-four cases within three months. In many of these cases, bony union was evident at the end of two months. External support through the use of crutches or a cane was continued for an average of five months. In none of the twenty-four cases was there any sign of aseptic necrosis of the femoral head. This experience is being duplicated by several of my associates who have been treating fractured hips by the method herein described. During the last two years, Dr. Max A. Rabinowitz, of Brooklyn, has treated ten cases of fracture of the neck of the femur—six subcapital and four intertrochanteric—by the procedure I have outlined and has obtained bony union in each case.

In addition to the cases herein included, I have treated several more by the method described, but have excluded them from this series for various reasons. Some are of too recent date. One woman in the late seventies died three days after the reduction from a cardiac attack. She had had many such attacks prior to the injury. Another woman of eighty-seven died three days after the reduction from a pulmonary embolism. Two service cases were accidentally discharged from the hospital too soon and cannot be traced. For the time being, I am concerned only with those patients in whom the treatment was carried out to completion.

I treated my first case according to the system described in February 1934 and made a preliminary report of the method in *The Journal of Bone and Joint Surgery* in October 1935. In the September 1936 issue of *Surgery, Gynecology and Obstetrics* there is an article on the "Ambulatory Treatment of Fractures of the Neck of the Femur" by Dr. George L. Apfelbach and Dr. Leon J. Aries of Chicago. Their method differs from the one I employ in only a few technical details. They, for instance, do not attempt a reduction of the fracture until five or six days after the injury. I can see no reason for such a delay except under extraordinary circumstances such as severe shock, hemorrhage, fracture of the skull with signs of intracranial pressure, etc. Certainly in the majority of cases, whether the patient is young or old, the sooner the fracture is set and immobilized, the sooner will the patient be relieved of pain and the resulting exhaustion.

SUMMARY

The results of the treatment by the system outlined have been so startling—in all cases in which the treatment was not interrupted by some intercurrent illness bony union was obtained—that they seem incredible in the light of our previous experiences. Perhaps it is merely good fortune in a small series of patients, but the facts that some of my colleagues who have used the method obtained equally good results, and that Dr. Apfelbach and Dr. Aries report a high percentage of bony union by a method which is practically identical with the one I use, encourage me to hope that accurate reduction, firm immobilization, and early weight-bearing will help solve the vexing problem of fracture of the hip.

REFERENCES

Apfelbach, G. L., and Aries, Leon J.: Ambulatory Treatment of Fractures of the Neck of the Femur. Surg. Gynec. Obstet., LXIII, 341, 1936.

Kleinberg, Samuel: Fracture of the Neck of the Femur. Report of a Case with Rapid Union Following Early Weight-Bearing. J. Bone and Joint Surg., XVII, 1041, Oct. 1935.

PATHOLOGICAL DISLOCATION OF THE SECOND TOE

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Pathological dislocation of the second toe is not a rare condition. In proof of this, the author wishes to report seven cases, five of which were treated at the Hospital for the Ruptured and Crippled in New York City. Four of the seven were seen during the last four months of 1936. The condition was first brought to the writer's attention by Dr. Raymond W. Lewis, Chief Roentgenologist of the Hospital for the Ruptured and Crippled. Only one case has been reported previously; this was described by Corrêa do Lago, Jr., as an unusual complication of hallux valgus.

This article will deal mainly with the cause of the deformity. The condition is becoming more common, because the high heels on women's shoes keep the toes in chronic hyperextension. There are definite reasons for pathological dislocation of the second toe instead of the other digits. Roentgenograms of two cases are shown in Figures 1 and 2.

FIG. 1

Case 3. Roentgenograms of the left foot, showing pathological dislocation of the second toe.

FIG. 2

Case 4. Roentgenograms of right foot, showing pathological dislocation of the second toe.

ETIOLOGY

Pathological dislocation of the second metatarsophalangeal joint is brought about over a period of months by a sequence of events that are so chronic that the deformity is apt to be unrecognized. The pain finally becomes so severe that the patient seeks medical treatment for her feet. The term "her feet" is used because all the cases thus far have been found in women, who wear high heels and walk with their toes in extension, which is the primary position for dislocation. There is no reason why pathological dislocation of the second toe should not occur in men if their toes are maintained in extension over a long period of time.

In order to explain the etiology of this deformity, it is necessary to give the essential anatomy and kinesiology of the human foot as found by dissection. The muscle distribution to the toes is not identical. The second toe has *two interossei dorsales* and no interosseous plantaris. The third and fourth toes have one of each of these muscles. The origin of each of the interossei dorsales is by two heads,—one from each meta-

tarsal between which the muscle is placed. The two interossei dorsales which control the second toe arise from the first and second metatarsals and from the second and third metatarsals, as shown in Figure 3.

Each muscle ends in a tendon just proximal to the metatarsophalangeal joint, which frays out over the dorsolateral or dorsomesial aspects of the base of the proximal phalanx. This tendon ends by fusing with the extensor tendons on the dorsum of the toe. So far, this coincides almost identically with the description in Gray's Anatomy. The function of these muscles is found to be the same as there described, provided that the toes are straight, but the function of abduction and adduction is changed when the first phalanx of the toe is in the extended position. By contracting first one and then the other of the interossei dorsales of the second toe, when that digit was extended, it was found that the base of the proximal phalanx was rotated dorsally, first on one side and then on the other. In conjunction with the normal extension force of the toe, there was a resultant line of pull which carried the base of that phalanx dorsally over the metatarsal head. This placed a strain upon the capsule of the joint, which, if continued over a long period of time, would stretch or tear the capsule and dislocate the toe.

FIG. 3

Dorsal view of the interossei dorsales muscles with the second toe in the claw position.

The two interossei dorsales of the second toe have dual innervations; the main supply is by the lateral plantar nerve from the tibial nerve, which is also distributed to the plantar flexor muscles of the foot. In addition, the first interosseous dorsalis frequently receives innervation from the medial branch of the deep peroneal nerve. The second interosseous dorsalis receives innervation from the lateral branch of the same nerve. The deep peroneal nerve is a branch of the common peroneal nerve which also supplies the extensor muscles of the foot. Thus it is possible for the two interossei dorsales of the second toe to contract when the foot is being flexed or extended. On walking, this would give a continual strain on the capsule of the metatarsophalangeal joint, provided that the toe was in sharp extension. The proximal phalanx is extended in the case of

high-heeled shoes, if there is a hammer-toe deformity, or if hallux valgus crowds the second toe over the dorsum of the big toe.

One other factor of importance is that the second toe is longer than any of the other digits. This is a direct cause of extension of the first phalanx, because of pressure from tight shoes or stockings.

Forces for Dislocation

To recapitulate, there are three sound anatomical and kinesiological reasons why the second toe should dislocate instead of its fellows:

1. The second toe is longer than its neighbor, and, therefore, is more subject to the pressure of tight stockings or shoes. Therefore, the

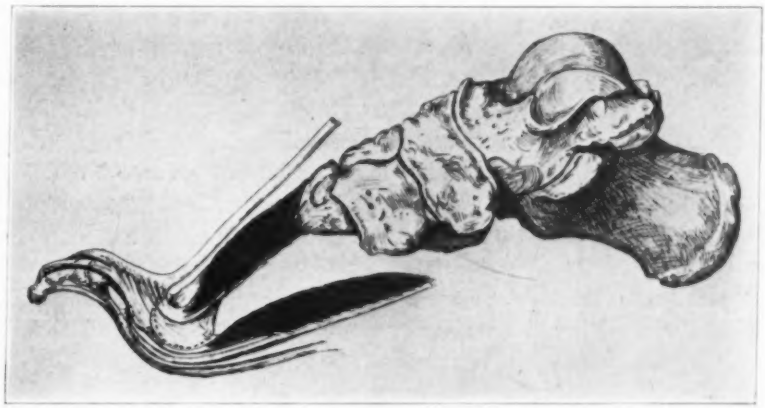

FIG. 4

Mesial view of the second toe with the first toe removed. The interossei dorsales and the lumbricales muscles are shown to illustrate their origins and insertions.

proximal phalanx, if not the whole toe, is more frequently held in hyperextension.

2. The second toe has two interossei dorsales and no interosseous plantaris. In the hyperextended toe these two muscles give a dorsally luxating force aided by the two extensor muscles.

3. The innervation of the two interossei dorsales of the second toe, in many cases, is dual not only through the nerve supplying the foot flexors but also through the nerve supplying the foot extensors. Thus the interossei may continue their dorsally luxating force whether the foot is flexed or extended.

Forces against Dislocation

The lumbricalis would help prevent dislocation if the toe were straight. However, in hyperextension of the proximal phalanx the force of the first lumbricalis, as clearly shown by Figure 4, is exerted, at right angles around the metatarsal head, on the extensor tendon. This gives the effect of extending the distal phalanx and of pulling the base of the

proximal phalanx directly upon the metatarsal head. Therefore, the force of the muscle contraction is reversed and pulls forward on its origin from the long flexor tendon, thus weakening the flexion power of that muscle. The long and short flexors of the toe exert some flexion power on the proximal phalanx, even though it is hyperextended. However, most of the flexion is exerted on the two distal phalanges and increased flexion merely drives the proximal phalanx backward, forcing the toe into the "claw" deformity. When this state is reached, the "forces for dislocation" frequently become stronger and more effectual than the "forces against dislocation", with the resultant dorsal luxation of the toe.

SYMPTOMS AND CLINICAL FINDINGS

The chief complaint in these cases is pain. There is usually a history of painful feet over a long period of months or years. Invariably the patients localize the pain at the metatarsal region, and, on being questioned, they state that the second toe is the offender. In most cases a long history of hammer-toe exists. In some cases there is a history of bunions over a period of years, and the big toe bends laterally, forcing the second toe up over the first. Painful calluses are present. The pain gradually increases until the patient cannot work. Strapping of the feet and arches and non-operative treatments do not cure.

Examination usually reveals a severe hammer-toe deformity of the second toe, or this toe rides up over the other digits. There is a hollow space under the plantar surface of the base of the second toe that lies over the dorsum of the metatarsal head. There is swelling or thickening at the base of the second toe which is tender to palpation. Lateral movement of the toe causes pain. The toe cannot be plantar-flexed, due to pain and to shortening of the interossei dorsales and the extensors. Calluses on the dorsum of the toe are common findings. Local heat and discoloration are absent.

Diagnosis of dislocation of the second toe can be made by the history and clinical findings. Roentgenographic examination clinches the diagnosis. However, anteroposterior, lateral, and oblique films should always be taken.

TREATMENT

Treatments by strapping with adhesive tape, splints, and arch supports have failed in every case. Operative correction is necessary. The operator may use his own judgment and devise his own operation, but the one essential thing is that he must shorten the toe to allow secure and adequate reduction. The procedure used by the author is described in Case 1.

CASE REPORTS

CASE 1. (Patient of Dr. Philip D. Wilson, Hospital for the Ruptured and Crippled, New York City.) J. A., white, female, aged sixty-two years, was examined on September 20, 1935. She had had pain in the metatarsal arches for years. At times she

had been unable to walk because of the pain. Arch supports had given no relief. Dislocation of the second toe of the right foot was confirmed by roentgenograms, and an operation was performed on October 22, 1935.

Under general anaesthesia and tourniquet control, a dorsal incision was made over the second toe. The metatarsophalangeal joint was exposed and the base of the phalanx was found to be dislocated dorsally on the metatarsal. When the capsule was opened, the articular surface on the metatarsal head seemed entirely absent, and the bone presented an eburnated surface. The metatarsal was resected just behind the neck. This allowed the base of the phalanx to be replaced. The end of the metatarsal shaft was drilled, and the long extensor tendon of the second toe was divided and its end was passed through the drill hole and sutured to itself with silk. The wound was closed, and a soft dressing was applied, with no splint.

The postoperative course was uneventful, and there has been complete cure.

CASE 2. (Patient of Dr. T. Campbell Thompson, Hospital for the Ruptured and Crippled, New York City.) C. P., white, female, aged thirty-two years, was examined on September 9, 1936. There had been gradually increasing pain in the second toe of the left foot for eight months, associated with swelling, and the patient had been unable to work. Dislocation of the second toe was confirmed by roentgenograms. An operation was performed on September 11, 1936, under local anaesthesia, followed by complete cure.

CASE 3. C. K., white, female, aged thirty-eight years, was examined on November 6, 1936. She had suffered from hammer-toe for years. There had been increasing pain in the second toe of the left foot. Roentgenograms (Fig. 1) revealed dislocation of the toe. Operation has been deferred until the callus and ulcer on the dorsum of the toe shall have cleared up.

CASE 4. E. H., white, female, aged forty-two years, was examined on November 16, 1936. She gave a history of painful feet for months, with severe pain in the second toe of the right foot. Roentgenograms (Fig. 2) revealed dislocation of the second toe. Operation was refused.

CASE 5. E. B., white, female, aged seventy years, was examined on December 28, 1936. She gave a history of flat feet, bunions, and hammer toes over a period of years. The big toe of the right foot crowded the second toe up over the dorsum, causing severe pain. Roentgenograms revealed dorsal luxation of the second toe. Operation was refused.

CASE 6. (Patient of Dr. F. C. Kidner, Detroit, Michigan.) M. F., white, female, aged forty-two years, was examined on January 14, 1937. She had had weak feet, bunions, and hammer-toe for seventeen years. Diagnosis of luxation of the second toe of the right foot was made during routine examination for acute low-back pain. The patient refused operation until the low-back pain should be relieved.

CASE 7. (Patient of Dr. F. E. Curtis, Detroit, Michigan.) A. S., white, female, aged thirty-five years, was examined on March 19, 1931. There was a history of pain in the feet for months; this was localized to the metatarsal arches and was worse in the second toe. Dislocation of the second toe was confirmed by roentgenograms. Operation, in March 1931, resulted in complete cure.

CASE 8. K. D., female, aged sixty-five, was seen recently by the author. She had had painful feet for many years. Examination showed a pathological dislocation of the second toe of the left foot and corns over the second toe of both feet. These toes tipped upward and were very tender, especially that of the left foot. Only temporary relief was secured by strapping, and operation was advised.

SUMMARY

Pathological dislocation of the second toe is a definite deformity that has not been dealt with in the medical literature of the world. There

has been one case reported previously. This deformity is not a rare condition, and it is becoming more common. The etiology has been explained on an anatomical, kinesiological, and neurological basis by showing that the line of force of the contracting muscles is altered by chronic hyperextension of the proximal phalanx of the second toe. The musculature of the second toe is different from that of the other toes. This has proved to be a definite etiological factor in the production of the dislocation.

The author wishes to thank Dr. Philip D. Wilson and Dr. T. Campbell Thompson of New York City, and Dr. F. C. Kidner and Dr. F. E. Curtis of Detroit for permission to include their cases in this article.

REFERENCE

CORRÊA DO LAGO, JR.: Uma complicação rara no "hallux-valgus." Rev. Brasileira de Cir., II, 489, 1933.

BONE REGENERATION FOLLOWING MAGGOT THERAPY IN COMPOUND FRACTURES

A Newer and Simplified Method of Maggot Application in Cases Complicated by Severe Comminution or Large Osseous Defects

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The results of treatment in severely comminuted compound fractures with gross infection and those complicated by large osseous defects are at best only mediocre. All too frequently a primary amputation is done by a surgeon who, as a result of his experience, has come to believe in the comparative hopelessness of any other form of therapy. He has found that conservative treatment offers no guarantee of a functional cure and, in addition, wastes a great deal of the patient's time in a useless effort. Access to an adequate supply of maggots led us to use them in this particular type of case, as well as in those of a less serious nature.

That the beneficial action of maggots in infected wounds has been long recognized is shown by the comments of Ambroise Paré and Larrey. Baer's independent observation during the World War stimulated interest in their use, so that at the present time many clinics, hospitals, and practitioners are utilizing this form of treatment. In this Hospital, the work of Fine and Alexander on the cultivation and use of fly larvae led to their use in selected cases. Since in Charity Hospital all osteomyelitis is treated on the Surgical Services, there has been little opportunity to observe any modification of the course of this disease by maggots. Some of the compound fractures treated were complicated by the loss of bony tissue, but excellent regeneration followed maggot therapy; this observation seemed of sufficient general interest to report.

Pomeranz has recently reported a certain type of bone regeneration following the use of maggots. In general, our findings closely resemble his, even though the bone defects in this series were larger than his. We have been unable to find any other comments in the literature on this subject.

MATERIAL AND METHOD

The maggots used were grown according to the technique described by Fine and Alexander[3].

FIG. 1

Case 1. Roentgenogram following accident.

FIG. 2

Case 1. Eight weeks after injury.

FIG. 3

Case 1. Six months after injury.

A rather detailed description of our present technique of the preparation and treatment of the wound is warranted because of its great variance with that generally followed. If the laceration of the skin is of sufficient size, no further opening is necessary. In the case of infected gunshot fractures and those in which the skin opening is small, an incision is made in the superficial tissues, roughly comparable to the area of bony comminution. No débridement is done and no attempt is made to remove any bone fragments save those grossly detached. The aim is simply to provide adequate exposure of the infected or contaminated areas. If gross hemorrhage is present, the wound is packed with vaselin gauze for twenty-four hours. If iodoform or other strong chemicals are used, the implanted maggots are speedily killed. No antiseptics are used for cleansing the traumatized skin, muscle, or bone.

The surrounding skin is generally swabbed with ether and covered for from two to three inches about the wound with vaselin gauze. Vaselin is used to diminish skin irritation. Many other dressings and solutions have been used to protect the skin, but none have proved any more efficient. A thin layer of sterile gauze is placed in the depths of the wound, eliminating dead spaces where possible. Under aseptic precautions a massive dose (approximately 5000 in number, representing about one cubic centimeter of fly eggs) of twenty-four-hour-old maggots, two to three millimeters in length, is removed from the sterile bottle with gauze

and laid on the gauze covering in the bottom of the wound. A dressing of sterile gauze, from four to six inches in thickness, is then applied. The usual dose of maggots is from 500 to 1000, so that the massive dose used by us represents five to ten times that amount.

The maggots immediately enter the traumatized area in search of food. As long as devitalized tissue or pus is present, or until the maggots attain their full growth (twenty-four to forty-eight hours), they will remain in the depth of the wound and will not stray. No cage or other means of retaining the maggots in the wound is used.

In response to the action of the larvae, a copious amount of thin, dark-brown exudate pours from the wound and is absorbed by the thick dressing. It is, therefore, necessary to change the superficial layers of the gauze dressing covering the wound every six to eight hours; otherwise the maggots would drown in the wound. As has been noted, the maggots mature in from twenty-four to forty-eight hours. From this time on they no longer will feed to any extent, but simply crawl from place to place and eventually, within from four to six days, pupate.

Since the larvae are comparatively useless in a wound during this latter period, we have consistently removed them. This is accomplished by the removal of the entire gauze dressing at the end of forty-eight hours, for, when the maggots are fully fed, they migrate from the wound into its covering. Comparatively few remain. They, in turn, may be removed by the later change of dressings. Generally speaking, none remain at the end of seventy-two hours.

The complications of maggot treatment are, in our experience, few and not serious. The most annoying is the pain experienced by some patients. Since the period of habitation in the wound by the maggots is short, we have routinely ordered sedatives or, if necessary, hypnotics or even narcotics. Skin irritation, occasionally disagreeable, has not been completely controlled.

As a result of the action of the maggots, several changes in the wound are noted. In contaminated but not infected lacerations, no pus or, at the most, very little pus is noted, and fine, clean, pink granulations rapidly appear, especially in the recesses where accumulations of exudate generally are seen. Grossly infected wounds are cleansed of the dirty, heavy, gray granulations present, the discharge of the pus is diminished, and the odor is made much more pleasant. In this type of wound, maggot implantations are necessary usually at intervals of ten to fourteen days in contrast to intervals of fourteen to twenty-one days in the simple contaminated wounds. Occasionally, one single dose of maggots has been sufficient. In those compound fractures with severe comminution we have not found sequestrectomy necessary in any case. The maggots loosen all non-viable bone fragments, making their removal a simple matter during the routine dressings. We have never found it necessary in any case of this type to take a patient to the operating room save for a primary incision.

CASE REPORTS

The following four cases are illustrative:

CASE 1. A. P., a white male, seventy years of age, sustained a compound comminuted fracture of the tibia and fibula (Fig. 1). The patient was seen seventy-two hours after injury. A severe infection required extensive incision. Skeletal traction by a Kirschner wire inserted through the os calcis was used for reduction and fixation. Eleven days after injury, maggots were applied for forty-eight hours. At the daily dressings numerous bone fragments were removed, until about ten centimeters of tibia was gone (Fig. 2). Traction was maintained for eight weeks. A fenestrated cast was then applied. In three months' time, there was complete healing of the skin. Several changes of casts were made. At the end of six months, the patient was allowed to walk, using a molded socket brace. Check-up roentgenograms at this time showed a complete fill-in of the defect in the tibia, definitely following the line of periosteal enclosure. (See Figure 3.)

CASE 2. J. H., a colored male, aged twenty-eight, sustained a compound fracture of the right tibia and fibula at the junction of the lower and middle thirds (Fig. 4). He was seen twenty-four hours after injury. A prophylactic dose of mixed serum was given, a Steinmann pin was inserted through the os calcis, and traction was applied. Twelve days after admission, maggots were applied and removed in forty-eight hours. Ten days later, the second dose of maggots was applied and removed in forty-eight hours. The oedema had disappeared, and the infection had cleared. The third application of maggots was given one week later and removed in forty-eight hours.

Eight weeks after admission, the roentgenogram (Fig. 5) showed a marked loss of tibial substance. A long leg plaster cast was applied and the patient was discharged

FIG. 4

Case 2. Roentgenogram following accident.

FIG. 5

Case 2. Eight weeks after admission.

FIG. 6

Case 2. Nine months after injury.

FIG. 7

Case 3. Roentgenogram following accident.

FIG. 8

Case 3. Seven weeks after injury.

FIG. 9

Case 3. Four months and one week after admission.

to the clinic. Nine months after injury, the roentgenogram was reported as showing "bony union in both bones and what appears to be a fusion of the callus between the tibia and fibula". (See Figure 6.) The patient was discharged, walking without support.

CASE 3. E. D., a colored male, thirty-three years of age, was shot in the left leg, causing a compound fracture of the tibia (Fig. 7). A few hours later, a "through and through" rubber-dam drain was inserted. A prophylactic dose of mixed serum was administered.

On the fourth day, a Steinmann pin was inserted in the os calcis, and traction was applied. The bullet wounds were enlarged and fifty cubic centimeters of gas-bacillus serum was given.

Three days later, maggots were applied for the first time and were removed after forty-eight hours. One week later, a fenestrated cast was applied. Eight days later, maggots were applied the second time for forty-eight hours.

Because of a marked soft-tissue infection, maggots were applied for forty-eight hours four times during the following month, and the cast was removed and replaced after each application. Roentgenographic examination (Fig. 8) showed that callus was present, but a section of the tibia, three and five-tenths centimeters in length, was missing.

Four months and one week after admission, the roentgenogram (Fig. 9) showed that the tibial defect was solidly filled in with callus.

CASE 4. O. O., a colored male, aged eighteen, was shot in the right thigh, causing a compound comminuted fracture of the femur. He was seen six weeks after the accident and examination showed marked infection, shortening of the femur of seven centimeters, and non-union (Fig. 10).

A Kirschner wire was put through the femoral condyles and traction was applied. Maggots were immediately applied and removed in forty-eight hours. Two large sequestrae (seven by two and five-tenths centimeters, and five by one centimeter) were lifted from the wound when the maggots were removed.

FIG. 12

Case 4. Five months after admission.

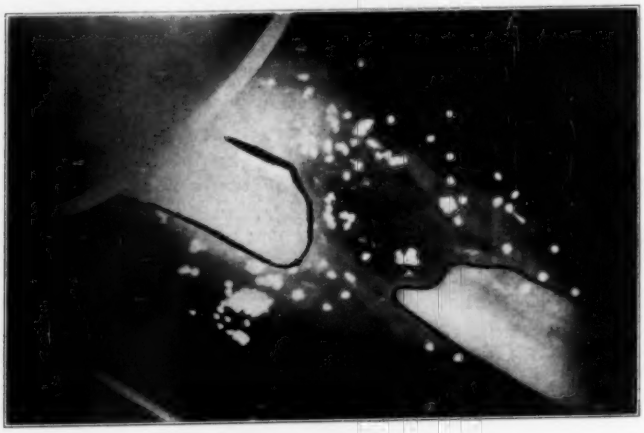

FIG. 11

Case 4. Eight weeks after accident (two weeks after admission).

FIG. 10

Case 4. Roentgenogram six weeks after accident (on admission).

Twelve days later, there was no shortening of the extremity. (See Figure 11.) Maggots were applied the second time. Many lead fragments were removed when the thigh was dressed.

After eight weeks of traction, there was good callus across the seven-centimeter gap, and a fenestrated plaster hip spica was applied. Six weeks later, the hip spica was reapplied. In eight weeks the patient returned and the cast was removed. The report of the roentgenographic examination was as follows: "Anteroposterior and lateral views of the right femur, in which previous views had shown extensive bone loss, now show good bone regeneration with the fragments in good alignment." (See Figure 12.)

Five months after admission, the patient was discharged, walking on crutches as he was unable to buy a weight-relieving caliper. There was no shortening of the leg.

DISCUSSION

The cases reported represent a selection from approximately fifty-five compound fractures treated by the use of sterile maggots. We believe that these cases were readily handled by this form of treatment because of the excellent exposure. That the same results could have been obtained by any other method now in use is extremely doubtful. Previous experience with other forms of therapy has not yielded the same happy results. In all cases save Case 4 the bone regeneration took place apparently within the confines of the periosteum. In this one instance the fragmentation of tissue by the shotgun charge was undoubtedly the determining factor.

The part played by the maggots in these severe bone injuries is problematic. That the infection is rapidly controlled by them is incontrovertible. It is probable that the final result is obtained through a combination of mechanical and chemical action [9, 10] and the antiseptic properties of the intestinal ferments of the maggots [7, 8].

CONCLUSIONS

1. In certain types of compound comminuted fractures, the massive dose of maggots used (5000 or more) in a short period of time (forty-eight hours) controls infection and removes loose bone particles without secondary operations.

2. Extensive bone regeneration follows this type of maggot therapy.

BIBLIOGRAPHY

1. Alexander, Howard: Personal Communication.
2. Baer, W. S.: The Treatment of Chronic Osteomyelitis with the Maggot (Larva of the Blow Fly). J. Bone and Joint Surg., XIII, 438, July 1931.
3. Fine, Archie, and Alexander, Howard: Maggot Therapy. Technique and Clinical Application. J. Bone and Joint Surg., XVI, 572, July 1934.
4. Livingston, S. K.: Maggots in the Treatment of Chronic Osteomyelitis, Infected Wounds and Compound Fractures. An Analysis Based on the Treatment of One Hundred Cases with a Preliminary Report on the Isolation and Use of the Active Principle. Surg. Gynec. Obstet., LIV, 702, 1932.
5. McKeever, D. C.: Maggots in Treatment of Osteomyelitis. A Simple Inexpensive Method. J. Bone and Joint Surg., XV, 85, Jan. 1933.
6. Pomeranz, M. M.: Peculiar Regeneration of Bone, Following Maggot Treatment of Osteomyelitis. Radiol., XIX, 212, 1932.

7. Robinson, William, and Norwood, V. H.: The Rôle of Surgical Maggots in the Disinfection of Osteomyelitis and Other Infected Wounds. J. Bone and Joint Surg., XV, 409, Apr. 1933.
8. Robinson, William, and Norwood, V. H.: Destruction of Pyogenic Bacteria in the Alimentary Tract of Surgical Maggots Implanted in Infected Wounds. J. Lab. and Clin. Med., XIX, 581, 1934.
9. Slocum, M. A., McClellan, R. H., and Messer, F. C.: Investigation into the Modes of Action of Blow Fly Maggots in the Treatment of Chronic Osteomyelitis. A Preliminary Report. Pennsylvania Med. J., XXXVI, 570, 1933.
10. Weil, G. C., Simon, R. J., and Sweadner, W. R.: A Biological, Bacteriological and Clinical Study of Larval or Maggot Therapy in the Treatment of Acute and Chronic Pyogenic Infections. Am. J. Surg., XIX, 36, 1933.

TREATMENT OF ACUTE BURSITIS BY NEEDLE IRRIGATION *

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Subdeltoid bursitis may be so painful as to require opiates and to render an upper extremity practically useless, and the disability may extend over a long period of time.

Rest, splinting, heat, diathermy, massage, and operative interference have thus far been the common forms of treatment. No one of these has been so uniformly successful that another form of treatment would not be welcomed by the profession.

Following out certain ideas and suggestions of Dr. M. N. Smith-Petersen, of Boston, during the past year at the Presbyterian Hospital in the City of New York we have treated sixty-three cases of subdeltoid bursitis by the irrigation method and have observed the facts mentioned in this paper.

SYMPTOMS

The patients were usually seen in the Emergency Ward and they complained of the ordinary symptoms of subdeltoid bursitis,—that is, pain in the shoulder, usually of acute onset, at first localized to the shoulder and then, depending on the duration of symptoms, extending over the entire shoulder region, even radiating down the arm to the region of the deltoid tubercle. The severity of the pain determined the amount of use in the arm. Some of the patients whose pain was of short duration (in several cases the duration was under twenty-four hours) were unable to take off their coats, to comb their hair, or to place their hands behind their backs. In the average case examination showed rather exquisite localized tenderness over the region of the subacromial bursa or over the supraspinatus tendon. There may or may not have been visible or palpable swelling in the same region. Except when the patient had been giving himself local heat therapy, there was rarely any evidence of redness or increased heat in the region of the shoulder. Two motions were always limited and painful,—namely, external rotation and abduction of the arm, actively or passively. In contradistinction to an intra-articular lesion, flexion and extension of the shoulder were usually not painful, if carefully done. Without exception, in each of the acute cases the patient carried the arm in a position of adduction and internal rotation with the forearm across the chest.

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Cleveland, Ohio, January 13, 1937.

ROENTGENOGRAPHIC EXAMINATION

At first, in the carrying out of the irrigation treatment, it was thought that a roentgenographic examination was essential to complete the diagnosis. However, after a short time, it was found that the roentgenogram might show calcium deposits, which was helpful, but as a rule it did not mean much. This statement is made for the reason that in several cases the roentgenograms (which were always taken in two positions,—internal rotation and as much external rotation as possible) failed to show any evidence of increased density in the region of the bursa, and, upon irrigation of the bursa, calciumlike material was obtained and was proved by chemical examination to be the same as that removed at operation from patients with chronic bursitis with calcification. Also, in several cases in which the patients were given the diagnosis of subacromial bursitis of several weeks' and even of several months' standing, the roentgenograms failed to show any deposits of calcium, and, upon irrigation, a gelatinous, synovial type of fluid was washed through, which, upon examination, showed the calcium and ordinary constituents of the bursa as described by Codman. Therefore, roentgenograms were taken as a routine, but they did not alter the treatment based on the clinical findings.

RELATION TO INFECTION

In the clinical quizzing of these patients an attempt was made to find out if there was any possible relationship between bursitis and a previous or present infection in the body. From a review of the past histories and examinations we can feel fairly certain that bursitis is not associated with any past or present systemic infection. Many of the patients had a white blood count of 14,000 with a percentage of polymorphonuclear leukocytes as high as 75. Some of them ran a temperature of 101 degrees by mouth. However, in not one single case was purulent material (cultures positive) obtained from the bursa on irrigation, and in not one case was there any evidence of infection after irrigation. Weeks states that in most of his cases some history of an upper respiratory infection preceded the onset of the shoulder symptoms.

METHOD OF IRRIGATION

Equipment

The equipment consists of the following: two 18-gage steel needles, two and one-half inches long; one 20-cubic-centimeter syringe; sixty cubic centimeters of 1-per-cent. novocain; a hypodermic needle; one No. 10 Bard-Parker blade; and as much saline as thought necessary (usually about sixty cubic centimeters).

Technique

With the patient lying on his back, the affected shoulder is prepared with iodine and alcohol. Then, with the hypodermic needle and novocain,

a small wheal is made in the skin over the point of maximum tenderness. This point usually corresponds to a spot about one inch lateral to and on the same horizontal line with the coracoid process of the scapula. Then, with the point of the scalpel, the skin is nicked through the epidermis. In like manner, a second point is infiltrated just about one-quarter of an inch posterior to the greater tuberosity of the humerus on a level with the superior facet.

FIG. 1

Position of needles in subacromial bursa. Note the relation of the anterior needle to the coracoid process of the scapula.

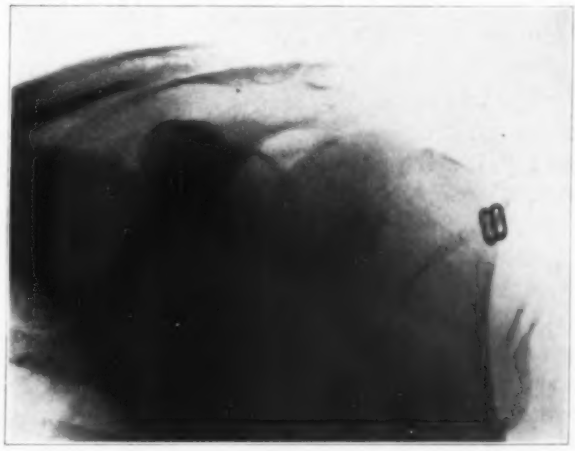

FIG. 2

Same shoulder as in Fig. 1, after the bursa had been irrigated.

Following the injection of the novocain, one of the large needles is introduced through the skin incision in the anterior portion of the anaesthetized region. The point of the needle is directed posteriorly and upward toward the under surface of the acromial process of the scapula. The needle is then pushed deeper and, after it has reached a depth of from one-half to three-quarters of an inch, the wall of the bursa can be felt as a definite resistance, provided that the syringe is held between the index finger and the thumb. A quick stab places the needle point within the bursa. At times, a cloudy fluid may push the plunger of the syringe back, due to the increased tension in the bursa. Following the placing of this anterior needle, a second one is inserted into the region just posterior to the greater tuberosity, about one fingerbreadth below the acromioclavicular joint. The needle is pushed gently down to the superior facet of the greater tuberosity and actual bone is felt with the

tip of the needle. Then the needle is slowly withdrawn for about one-eighth of an inch and the tip of the needle is pointed in the direction of the assumed position of the tip of the anterior needle which is in the bursa. After this needle has been inserted for about one-half of an inch, the bursa is entered. Two cubic centimeters of novocain is used in each of the needles on the way down to the bursa and on going through the bursal sac.

As soon as the two needles are in place, the syringe is filled with normal salt solution and this is pushed through one needle to flow out the other. A material of the consistency of toothpaste, either homogeneous in appearance or crystal-like, may exude. At times it is so thick that it almost stops up the needle, and considerable force is required to push it through. With the 20-cubic-centimeter syringe full of saline, it is possible to force the solution out the other needle for a distance of twenty-one inches beyond its hilt. This can only occur when all the calcium has been washed out and the two needles are in perfect position. At this stage, there seems to be only one advantage in having calcium show in the fluid on washing,—it makes one absolutely certain that the needles are in proper position and the bursa is being washed as clean as possible.

Usually, as soon as one syringe of salt solution has been pushed through, the patient states that the acute pain has disappeared. The amount of saline used to wash the bursa clean varies from thirty cubic centimeters to sixty cubic centimeters. The needles are then withdrawn and a small sterile dressing is applied to the region of the shoulder. Following this, the patient can usually move the arm freely in all directions without pain. At first he is reluctant to do so, because he has had so much discomfort; this is especially true in the acute cases. Gentle passive manipulation can be done without harm and with actual benefit in cases of long standing. Often a definite give to the shoulder can be felt.

It is important to remember that in the use of the irrigation method as little salt solution as possible should be allowed to exude into the surrounding tissues. If this is prevented, on the following day the patient's arm will not be sore as if a hypodermoclysis had been given in the arm. He is better able to use the arm and to return to work more quickly.

In certain very sensitive individuals it is advisable to use gas-oxygen anaesthesia instead of local anaesthesia. Some of these patients have had so much pain that they cannot stand any procedure on the shoulder during the acute stage unless they are asleep.

TREATMENT FOLLOWING IRRIGATION

Immediately following the irrigation, the first of our patients were kept in the over-night ward; in each case the arm was suspended in a position of abduction and external rotation, and heat was applied in the form of thermolight. Early motion was requested. On the next day the arm might be sore when the patient attempted to move it in extremes of motion, but the original acute pain had disappeared. The patient was seen in the Clinic on the succeeding days. However, after the technique

had been improved, we discontinued this postirrigation treatment. The arm was placed in a sling and, if the patient was of the stoical type, he was allowed to go home and told to use the arm and move it only when he felt like it. No haste was made, with the result that on about the fourth to the sixth day the patient had full use of the arm without pain. Some of the patients had symptoms as long as nineteen days, but they could use their arms and sleep after the irrigation. We think now that, when a patient has had acute pain for a few days and, consequently, has been unable to sleep and is irritable, nervous, and worried, it is best to keep him in the hospital for a day or so. The irrigation can be carried out in the office, but we do not recommend it. Although we have not had an infection in any of these cases, there is always that possibility and we feel sure that there is less chance that anything may go wrong in the hospital than in the office.

DURATION OF DISABILITY

One of our primary reasons for writing this paper is to show that at present we have a form of treatment for acute subacromial bursitis that does not entail the period of economic disability common to the other forms of treatment. Codman states in his book that these patients are sure of being cured by operation and that, following the operation, the average period before symptoms subside and the patients are able to return to work is between two and six weeks. Since in the irrigation treatment the period of disability is less than a week, its importance can be seen. Furthermore, there have been no recurrences of symptoms in the acute cases in which irrigation has been properly carried out, and we have many cases which have been followed over thirteen months.

TABLE I

SUMMARY OF CASES TREATED BY IRRIGATION

Treated by irrigation		63 cases
Acute (7 days or under)	48 cases	
Subacute (under 1 month)	8 cases	
Chronic (over 1 month)	7 cases	
Histories of previous attacks		17 cases
Roentgenograms showed calcium shadows		48 cases
Average period of economic disability:		
Acute		4.8 days
Subacute		7.0 days
Chronic (when relieved)		10 – 14 days
Results:		
Complete relief of symptoms		57 cases
Infections		0 cases
Limited motion in shoulder		2 cases
Operation necessary after irrigation		2 cases
Pain and limited motion still present		2 cases

Note: Only one of the six cases included in the last three groups was acute.

SELECTION OF CASES

Not every patient with bursitis was immediately subjected to irrigation upon entering the Hospital. In addition to the sixty-three cases treated by the irrigation method, there were, during the year 1935 to 1936, 105 other cases treated by various methods. At first irrigation was done in every case, but later we learned which cases would respond best to this treatment. The other cases were treated either by physiotherapy in the form of diathermy and static brush or by operation. We found that irrigation was most successful in the following types of cases:

1. Very acute cases without history of previous attacks.

2. Cases in which the calcium, as seen in the roentgenogram, was fuzzy—not dense, round, or bonelike—and gave the appearance of not being in the tendon of the supraspinatus muscle.

FIG. 3

This demonstrates the necessity for more than one view. With the arm in partial external rotation, there is increased density in the anterior region of the head of the humerus. This is very easily overlooked. (See Fig. 4.)

FIG. 4

With the arm in internal rotation, a dense, elongated calcium shadow can be seen. This is incompletely visualized with the arm in external rotation.

3. Cases in which the acute pain was localized to one spot and did not radiate.

Taking as criteria immediate complete relief of pain and the length of time before the patients returned to work, the most successful results were obtained in cases of very acute nature with symptoms of only a few hours' or a few days' duration. The patients who enter, holding the arm by the side, begging for relief, not wishing even to be examined, and stating that, while combing the hair a few hours previously, they suddenly had had pain in the shoulder and since then have not been able to move the arm or to touch the shoulder, we feel sure will respond well

to this irrigation. Not all of the cases in this series were of this sudden onset as can be seen from Table I. We can say positively that certain of the cases diagnosed as chronic bursitis, in which an ache of long duration was present in the shoulder, and in which there had been occasional flare-ups, were relieved by the irrigation method, as shown by the following case.

FIG. 5

A dense calcium shadow is seen in the region of the supraspinatus tendon. Attempted irrigation failed and an additional roentgenogram was taken. (See Fig. 6.)

A woman, fifty-five years old, had had the subacromial bursa removed from the left shoulder two years before entering the Hospital. For fourteen months prior to admission she had had a constant ache in the right shoulder, which became worse at night, and it had been necessary to place a pillow under the elbow in order that she might sleep. Local heat, massage, and diathermy had failed to give her any relief. The bursa was irrigated and a clear fluid, as described in the early part of this article, was washed out. The patient was immediately free from symptoms, and slept well the first night. Suddenly, at the end of ten days, she again had acute pain in the shoulder. A second irrigation was done, and, for the past eight months, she has been asymptomatic. Roentgenograms in this case were negative.

FIG. 6

With the humerus forced into external rotation, definite calcification is seen in the subacromial bursa. Irrigation was again done, a good flow was obtained, and complete relief followed.

After a number of these cases had been studied, the rule was adopted that, when a patient entered the Emergency Ward with a history of pain and discomfort of long duration, he was to be sent to the Physiotherapy Department for diathermy, massage, and baking. If at the end of a reasonable period of time (approximately six weeks), he was still having difficulty, then irrigation was to be done. Some of these patients showed improvement and some of them did not. Operation was then resorted to in the unrelieved cases.

As a general rule, the absence or presence of calcium in the roentgenogram does not make much difference. However, those cases in which roentgenographic examination shows the presence of calcium of a decreased density and fuzzy appearance, apparently generalized throughout the bursa and not localized in the supraspinatus tendon, belong to the group that respond better to the irrigation method. If from the roentgenographic appearance the calcium deposits are hard, smooth in outline, of markedly increased density, and apparently in the tendon of the supraspinatus muscle, we have learned that irrigation, even under the fluoroscope and with the attempt to break up the deposits with the point of the needle, does not seem to have any effect. Therefore, these cases are considered surgical.

In two of our cases the calcium shadow in the roentgenogram was soft in appearance in some spots and in others appeared to be hard and bonelike. Irrigation was done and in neither case was there any relief from the acute pain, even though the soft calcium was washed out. Both patients had histories of previous attacks. Within a few days after the irrigation, they were operated upon and the bursae and tendons were examined. In each case the bursa was found to be slightly reddened but clean except for an occasional piece of the soft calcium material in the lining of the wall. An elevation in the floor of the bursa showed a deposit in the tendon of the supraspinatus. When the tendon was incised there was a puffing out of the toothpaste-like material as though it were under pressure in the tendon. Both patients obtained complete relief after the operation. This small amount of calcium flakes in the bursa is often seen in the roentgenograms taken after irrigation. We have many cases in which there is present apparently the same amount of calcium after the washing as before and yet, following the irrigation, the patients are entirely asymptomatic.

When the calcium deposits are felt with the tip of the needle to be hard and rocklike and the roentgenographic appearance is similar to that just described, we feel fairly sure that radical excision, rather than irrigation, should have been the method of choice.

When the patient enters complaining of acute pain in the shoulder, localized to one spot, and when, upon examination, there is a definite localized area of tenderness, then we immediately feel more confident of the result than if there is a generalized distribution of pain. In the cases in which the pain was of more than a few days' duration and had become of a radiating nature, there seemed to be one spot to which this radiation extended,—namely, the region of the deltoid tubercle. It is true that later the pain may go up the side of the neck and down the arm to the finger tips. If, after a week or so following the irrigation, the patient has an occasional twitch in the shoulder or any discomfort on extremes of motion, he will usually state that the difficulty is in the region of the deltoid tubercle. In one case in which the patient complained of pain in the region of the tubercle only, the roentgenogram revealed calcification in the supraspinatus tendon. A needle was placed in the bursa, with the

use of novocain in the skin only. This procedure was done under the fluoroscope. When the point of the needle was seen to touch the deposit and the tendon of the supraspinatus was felt to move with it, the patient immediately cried with pain referable only to the region of the deltoid tubercle. Into the deposit was injected two-thirds of a cubic centimeter of novocain, and the pain immediately disappeared. Two hours later the patient again complained of pain in the region of the deltoid tubercle. The significance of this pain distribution we are at present unable to account for.

FIG. 7

A soft, homogeneous calcium shadow is dispersed throughout the bursal sac. This type of case responds exceptionally well to the irrigation treatment.

This irrigation method has been tried in several other cases of chronic subdeltoid bursitis, which have not been recorded in this series. Some of the patients have been relieved and others have not. The throbbing ache of which some of them complained has been relieved by irrigation and the outlook has been good, but the follow-up examinations show that these patients still have limitation of motion and occasional aches. At present, we cannot recommend simple irrigation for the cases of many years' duration in which the roentgenograms show no evidence of calcification. That the irrigation actually did help a few of the chronic cases cannot be overlooked, but, until we know more of the actual results of the treatment, it is probably better to limit irrigation to the acute and subacute cases.

We have also irrigated several bursae other than that of the shoulder—the subtrochanteric bursa, the semimembranosus bursa, the subscapularis bursa, and the olecranon bursa—and have obtained good results. In acute bursitis in any of these regions we recommend irrigation and can promise excellent results provided that a good flow is obtained through the two needles.

SUMMARY

1. Sixty-three cases of subdeltoid bursitis were treated by the simple irrigation method.

2. The results, evaluated on the basis of relief of the acute pain and on getting the patients back to work earlier than with any other form of treatment, seem to warrant its use.

3. The average period of economic disability following the irrigation is 4.8 days in the acute cases. There have been very few recurrences of

symptoms in the acute cases (some of the cases have been followed for over thirteen months).

4. Irrigation is not desirable in cases in which the roentgenograms show old calcification with a hard, bonelike appearance, probably in the supraspinatus tendon. To show calcium, roentgenograms should be taken in as much internal and external rotation as possible.

5. Irrigation did no harm in any of our cases; it may, therefore, be tried in any case, but it is recommended primarily for the acute cases with localized signs and symptoms.

REFERENCES

CODMAN, E. A.: The Shoulder. Rupture of the Supraspinatus Tendon and Other Lesions in or about the Subacromial Bursa. Privately published, 1934. (227 Beacon Street, Boston, Massachusetts.)

WEEKS, ALANSON, AND DELPRAT, G. D.: Subdeltoid Bursitis (Acute). Internat. Clin., III, 40, 1936.

CLINICAL EVALUATION OF COLLOIDAL SULPHUR IN THE TREATMENT OF ARTHRITIS

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The importance of this problem has been reported in the recent survey of chronic diseases in Massachusetts, which revealed a greater incidence of rheumatism than of heart disease, tuberculosis, and cancer combined. In the Veterans' Administration, as well as in general life, this is an important factor.

The development of biochemistry and research work in colloidal chemistry has demonstrated the importance of the sulphur molecule as a protective mechanism against intoxication. Colloidal-sulphur therapy, therefore, has opened an avenue which promises to lead to more permanent results than have been obtained heretofore.

It is desired to emphasize the necessity for collaboration between the clinician and the biochemist on the one hand and the bacteriologist and pathologist on the other, the present position being not one of divorce, but of disengagement.

A number of published articles apparently were subjected to some criticism, as a parallel study with colloidal sulphur and other medication had not been made. The colloidal-sulphur régime in the treatment of arthritis was introduced by the writer at the Veterans' Administration Hospital, Bronx, New York, in 1932. These patients under observation had been treated for a number of years with vaccines and other antirheumatic medications, including special dietary measures. The results were not very satisfactory until the administration of colloidal sulphur was instituted in sufficiently large doses. We were primarily interested in obtaining relief and in reducing the economic loss created by this disease.

SULPHUR THERAPY

Colloidal sulphur, as originally used, was supplied in two forms: two-cubic-centimeter ampules, containing twenty milligrams of colloidal sulphur in acid-free olive oil, for intramuscular administration; and five-cubic-centimeter ampules, containing thirty milligrams of colloidal sulphur in aqueous solution of dextrose, for intravenous administration. Originally, a dose of ten milligrams of colloidal sulphur was administered intravenously, but it was found that the larger doses—thirty-milligram or five-cubic-centimeter doses—gave a better response and there were no untoward results or systemic reactions. In cases of severe type and of long standing, with low cystine content of the finger nails and a high sedimentation rate, thirty milligrams of colloidal sulphur was given every day until a course of ten injections had been administered. More satisfactory results were obtained from the intravenous administration, and the in-

tragluteal injections are now given only to patients in cases where it is impossible to penetrate the vein.

In the majority of cases (over 78 per cent.), the patients were free from pain after the fifth or sixth injection, and the spasticity of the muscles began to disappear. The effusion in the joints gradually became less, and, after about three or four weeks of treatment, it was practically gone.

When giving colloidal sulphur intravenously, great care should be taken to disperse it slowly and to prevent any leakage into the soft tissue, as the latter causes excruciating pain and sometimes sloughing of the soft parts at the vicinity of the point of injection. There is no evidence of any toxicity or other ill effects resulting from the proper administration of colloidal sulphur.

The patients treated received from two to three courses of colloidal sulphur of ten injections in each course, with the exception of the patients with muscular rheumatism, who received only one course. The average duration of treatment was ninety days.

SULPHUR COMPLEXES AS OUR PROTECTIVE MECHANISM

It is not amiss to state at this time that the part played by disordered metabolism in the production of atrophic arthritis has not received the attention it warrants. Considering that arthritis is a metabolic disturbance, superimposed by infection or some other unknown factor, it becomes necessary to deal with the changes in the process of oxidation, reduction, and impaired compensation. One of the most important facts is the change in the protein metabolism, involving increased formation of amino compounds. As an example, histamine, which is highly toxic, has definite physiological action and is one of the most important of the group. Normally, it combines with the loosely bound sulphur molecule and is eliminated. Pyman states that the potent physiological base as histamine loses its physiological activity when combined with sulphur.

It is a well-known fact that indole is oxidized to indoxyl when combined with sulphur, and is eliminated as indican. It is apparent that the loosely bound sulphur molecule plays an important rôle in the body activities as a part of our protective mechanism against toxins produced in the body.

This loosely bound sulphur in the form of glutathione and its products, cystine and cysteine, are the normal available substances furnished by the liver, and are the necessary constituents of the tissue cells. The evidence to date shows that glutathione plays an important part in the cellular respiration, oxidation, and reduction, which stimulate enzymatic activities. Cystine is present in definite quantities in the skin, hair, and nails. Du Vigneaud found a high cystine value in insulin. Sullivan and Smith found close parallelism between the loosely bound sulphur and the active principle of the posterior pituitary body. Sullivan and Hess reported cystine in a large number of vitamins, enzymes, and some other hormones.

It has been previously reported that, in the majority of arthritic cases, the low cystine content of the finger nails points toward an intoxication factor which utilizes sulphur complexes and thus diverts the cystine sulphur from the finger nails. The increase of cystine in the nails of arthritics after the injection of colloidal sulphur indicates that sulphur compounds, directly or indirectly, combine with the injurious material.

Sullivan and Hess reported that 65 per cent. of arthritic patients have an average cystine content of 9.08 per cent. in their finger nails, while the normal cystine is never below 11 per cent., and should be about 12.5 per cent. This work was substantiated by Neligan and Salt of England. Meyer-Bisch, in 1922, stressed the importance of sulphur metabolism in general body activities. Recently, numerous clinical reports on the value of colloidal-sulphur therapy in the treatment of arthritis have been published. In 1934 and 1935, the writer reported the results on 250 cases. Seventy-eight per cent. of these patients responded favorably to the treatment. Since the last report, we have had under treatment 106 more cases, showing equally good results, making a total of 356 cases treated. Senturia, Wheeldon, Rawls, and others have also reported favorably on the same subject.

In selecting cases for this treatment, it is necessary to take into consideration that colloidal-sulphur therapy will not restore injured and broken-down joints, nor will it correct deformities. These can be accomplished only by the institution of proper orthopaedic measures. Experience has shown that administration of colloidal sulphur will arrest further progress of the disease, relieve the patient of pain, reduce the spasticity of the musculature, decrease the effusions in the affected joints, and promote the restoration of the individual to a state of economic usefulness. The treatment is of equal value in chronic and acute cases as long as pain, swelling, effusion, and spasticity of the muscles are present.

CONCLUSIONS

1. The author is quite aware of the hypothetical character of some of the views expressed, but there must be imagination and play of ideas at the root of progress in science. It would seem that the views as to the nature of this disease must become more catholic. Following further clinical observation, it is felt that slowly but steadily a better and more complete understanding of this problem will be reached.

2. It is believed that arthritis is a metabolic disorder, superimposed by infection or some other unknown factor, causing a break in compensation.

3. The early administration of colloidal sulphur in cases of acute and chronic arthritis is of importance in order to prevent unnecessary suffering, prolonged invalidism, and deformities.

4. Our studies point to the restoration of metabolic stability as a necessary aim in treatment of arthritis.

5. It is the opinion of the writer that colloidal sulphur assists in restoration of metabolic stability.

6. The experience with 356 cases treated over the past five years warrants the conclusion that colloidal-sulphur therapy is of great value in the treatment of this malady.

REFERENCES

Du Vigneaud, Vincent: The Sulfur of Insulin. J. Biol. Chem., LXXV, 393, 1927.

Hopkins, F. G.: On an Autoxidisable Constituent of the Cell. Biochem. J., XV, 285, 1921.

On Glutathione: A Reinvestigation. J. Biol. Chem., LXXXIV, 269, 1929.

Meyer-Bisch, R.: Ueber die Wirkung parenteral verabfolgten Schwefels. Ztschr. f. klin. Med., XCIV, 237, 1922.

Neligan, A. R., and Salt, H. B.: Sulphur in Rheumatoid Arthritis. Lancet, II, 209, 1934.

Pyman, F. L.: 2-Thiol 4 (5)-β-Aminoethylglyoxaline (2-Thiolhystamine). J. Chem. Soc., XXX, 98, 1930.

Rawls, W. B., Gruskin, B. J., and Ressa, A. A.: The Value of Colloidal Sulphur in the Treatment of Chronic Arthritis. J. Am. Med. Sciences, CXC, 400, 1935.

Senturia, B. D.: Results of Treatment of Chronic Arthritis and Rheumatoid Conditions with Colloidal Sulphur. J. Bone and Joint Surg., XVI, 119, Jan. 1934.

Sullivan, M. X.: Sulphur and Cystine in Relation to Arthritis. Med. Ann. District of Columbia, III, 233, 1934.

Sullivan, M. X., and Hess, W. C.: Cystine Studies in Arthritis. J. Biol. Chem., XCVII, xxv, 1932.

The Cystine Content of the Finger Nails in Arthritis. J. Bone and Joint Surg., XVI, 185, Jan. 1934.

Sullivan, M. X., and Smith, M. I.: Loosely Bound Sulphur in Pituitary Extracts. Pub. Health Rep., XLIII, 1334, 1928.

Wheeldon, T. F.: The Use of Colloidal Sulphur in the Treatment of Arthritis. J. Bone and Joint Surg., XVII, 693, July 1935.

Wheeldon, T. F., and Main, R. J.: The Use of Colloidal Sulphur in the Treatment of Arthritis. J. Bone and Joint Surg., XV, 94, Jan. 1933.

Woldenberg, S. C.: Sulphur (Colloidal) Therapy in the Treatment of Arthritis. With Report of One Hundred Cases. Med. Record, CXXXIX, 161, 1934.

Sulphur (Colloidal) Therapy in Treatment of Arthritis. Med. Bull. Vet. Admin., XII, 10, 1935.

The Treatment of Arthritis with Colloidal Sulphur. Report of 250 Cases. Southern Med. J., XXVIII, 875, 1935.

A PECULIAR SYSTEMIC DISEASE OF THE SPINAL COLUMN (PLATYSPONDYLIA AORTOSCLEROTICA)

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This paper is concerned with a peculiar disease of the vertebral column which we have not found described, and which seems not to be very common, for six cases only have been observed by us in the course of five years; nevertheless, the findings are so definite and distinctive that they seem to warrant the following report.

Clinical signs and symptoms are not characteristic and may even be absent. Occasionally there is some complaint of pain in the back and of being easily fatigued. Three patients noticed that they had grown a little shorter in stature during the preceding two or three years. In two of these cases, the gradual formation of a gibbosity was observed by the patients themselves or by members of their families. The youngest patient in our series was fifty-two years of age; the oldest, seventy-six. Two of them were males and four were females. Four were Orientals, one was a Russian, and one an Anglo-Saxon. One was a merchant, two were housewives, and three were employed in offices. Except for the two cases in which a gibbosity had formed, the condition of the spine was discovered accidentally during roentgenographic examinations of the chest and abdomen, as examination of the spine had not been asked for by the clinicians. This shows how slight or indefinite were the clinical symptoms induced by the disease,—a fact which contrasts strongly with the very pronounced changes shown on roentgenographic examination.

The roentgenographic findings are as follows:

1. Generalized demineralization of the whole spinal column, without similar decalcification of other parts of the skeleton.

2. Flattening of the bodies of a number of vertebrae, with concavity of their upper and lower borders.

3. Marked widening of the intervertebral spaces, which appear rounded because of the concave borders above and below them.

4. Extensive calcification of the aorta, both in the thoracic and in the abdominal portions.

It is evident that we have to do here with a morbid entity, characterized by a high degree of sclerotic calcification of the whole aorta, together with a systemic disease of the vertebral column, marked by softening of the bodies of a variable number of vertebrae. The intervertebral discs are not involved, at least not primarily, but they expand and encroach upon the space originally occupied by the adjacent and now softened bones. No signs are found of any such bony hypertrophic reactions as occur in almost all inflammatory affections of the spine; furthermore,

there is no evidence of arthritis in the apophyseal articulations. On the other hand, slight calcifications in the longitudinal ligaments are to be seen occasionally. Accordingly, we may conclude that this disease falls, nosologically, into that group of rare conditions in which the leading sign is widening of the intervertebral spaces.

Much roentgenographic evidence has accumulated in recent years as to the reciprocal relations subsisting between the intervertebral discs and the adjacent vertebral bodies. Building upon the foundations laid by Schmorl and his pupils, Keyes and Compere, Norlén, Calvé, Galland, Geist, Moffat, Wagoner

FIG. 1

Typical aspect in an advanced case, showing compression of the midthoracic and upper lumbar vertebrae (*x*) and extensive aortic calcification (arrows). The cervical and upper thoracic portions of the spine were normal; the lower thoracic vertebrae show very slight change.

FIG. 2

The lumbar spine, showing pronounced aortic calcification. Note that the upper lumbar vertebrae (*x*) are more affected than the lower.

FIG. 3-A

FIG. 3-B

Early stages of the disease in the lumbar spines of two patients. Note the similarity of the findings. The upper vertebrae are more affected; the intervertebral spaces are wider than those below. The arrows denote moderate aortic calcification. Similar changes were present in the midthoracic spine.

and Pendergrass, Smith, Turner, Oppenheimer, and others have shown that the elasticity and the hardness, respectively, of discs and of vertebral bodies are important factors in the pathogenesis of certain spinal diseases. Collapse or thinning of discs may lead to abnormal mechanical stress on the intervertebral ligaments and periosteum of adjacent vertebrae, which respond by the formation of calcifications and exostoses, resulting, finally, in the development of bony bridges over the narrowed interspaces (Schmorl's "deforming spondylosis", or hypertrophic spondylitis of the Anglo-Saxon literature). Vertebral infections (typhoid fever, Malta fever), injuries, and metastatic malignant infiltrations often produce similar reactive excrescences. Especially noteworthy, however, is the fact that primary thinning of the disc is a very common cause of spondylosis; wherefore, in a previous report [12], the term "discogenetic disease" was suggested to designate this form. Furthermore, Oppenheimer and Turner have observed that thinning of the discs in one section of the spine may be associated in another with fragility of the vertebrae and consequent protrusion or herniations of the nucleus pulposus into the softened

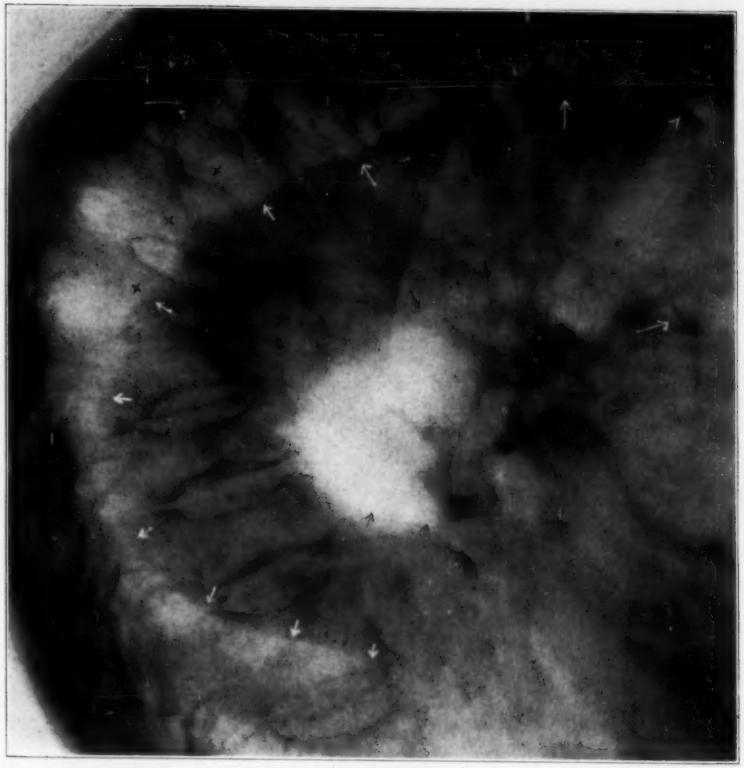

FIG. 4

The thoracic aorta is tortuous, elongated, and partly calcified (arrows). Note the pronounced density of its shadow. Three vertebrae (x) have collapsed.

FIG. 5

Extensive densification with calcareous deposits in the thoracic aorta (arrows). Two vertebral bodies (x) are greatly flattened.

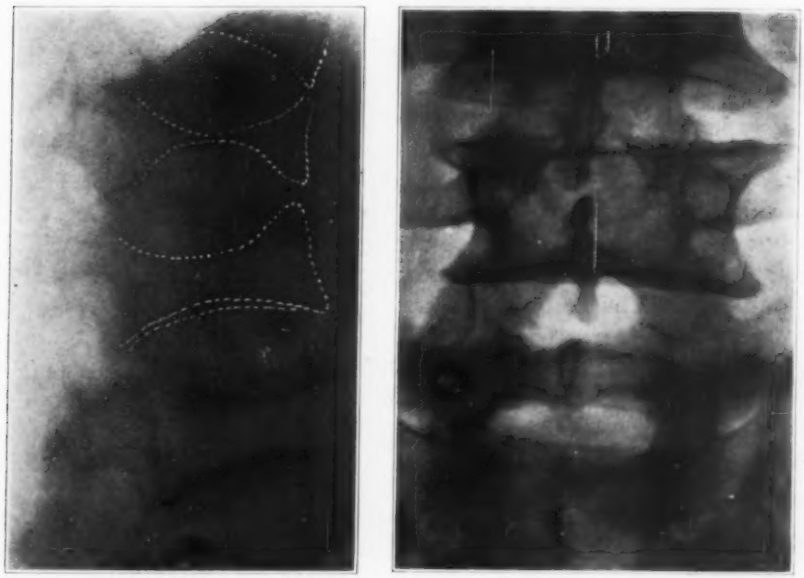

FIG. 6-A FIG. 6-B

Widening of the intervertebral spaces:
Fig. 6-A: In Gaucher's disease (retouched).
Fig. 6-B: In an elderly porter.

bony surfaces of the contiguous vertebrae; accordingly, they conclude that thinning of the discs, unless consequent upon recent or remote trauma, is a degenerative disease which may have its origin in disturbances of nutrition (as produced experimentally by Bernstein). However, the morbid condition discussed in this paper is the converse or complementary picture, as it were, of the discogenetic disease.

It has been shown by Baron and Bársony, Smith, Moffat, Wagoner and Pendergrass, and others that softening of the vertebral bodies allows a normal disc to expand in proportion to the diminution of the bony resistance that the vertebrae normally oppose to the elastic expansibility of the disc. This occurs, for example, when a morbid process in the vertebral body has not yet involved the disc. As the disc receives its nutriment exclusively by diffusion from the vertebral bodies (through their lamina cribrosa), it depends upon the nature, extent, and degree of the morbid process in the bone whether the disc shall be affected simultaneously with the vertebra, or later, or whether the disease shall be arrested before the disc is involved (or without involving the disc). For example, there are certain rarefying conditions in which the process is for many years confined strictly to the bones, which become more and more flattened, while the discs expand correspondingly; this is known to occur in tuberculosis, after fractures, and in Gaucher's disease (Fig. 6-A). We have also observed multiple formation of "vertebra plana" after injury in persons who have soft vertebrae, as shown by generalized widening of the intervertebral spaces in sections of the column not affected by the trauma

(Fig. 7). In three cases of this nature, examined during the last two years, laboratory tests revealed neither abnormalities of calcium metabolism nor any other signs of hyperparathyroidism. Slight widening of the intervertebral spaces may occur also in ankylopoietic spondylarthritis of the Bechterew type (Fig. 8-B) or in the group of diseases associated with calcification of the longitudinal ligaments without involvement of the articulations (spondylosis ossificans ligamentosa) (Fig. 8-A). Finally, one may occasionally find moderate flattening of vertebrae with slight enlargement of the intervertebral spaces and moderate exostotic formations in patients subjected to excessive and prolonged mechanical stress, as, for example, porters in Oriental seaport towns (Fig. 6-B).

From the morbid conditions mentioned, the one under discussion is distinguished by its coexistence with a high degree of calcification of the aorta, especially in its abdominal portion, and by a more or less characteristic localization of the morbid process. Although the disease is systemic, the changes are most marked in the midthoracic section of the spine, at the thoracolumbar junction, and in the upper lumbar vertebrae, in

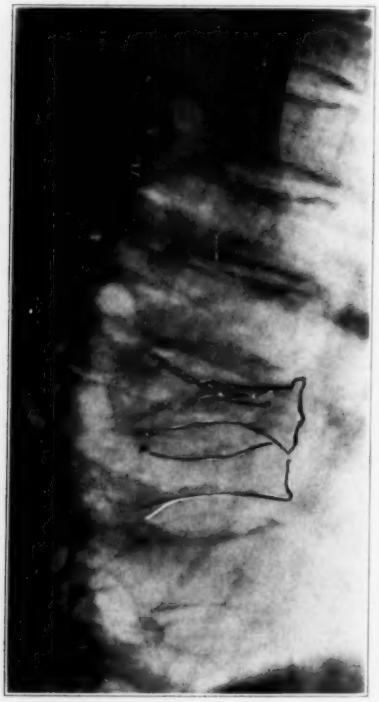

FIG. 7-A

FIG. 7-B

Roentgenograms of a woman, thirty-two years of age, showing compression fractures of four vertebrae and expansion of the discs in the lower lumbar spine which is not affected by the trauma. There is no aortic sclerosis.

FIG. 8-A

FIG. 8-B

Slight widening of the intervertebral spaces:

Fig. 8-A: In spondylosis ossificans ligamentosa. Note the calcification of the anterior longitudinal ligaments (*x*) in the absence of any changes of the apophyseal articulations (arrows).

Fig. 8-B: In ankylopoietic spondylarthritis. Note ankylosis of the lower apophyseal joint (black arrows) and roughening of the facets in the upper apophyseal joint (white arrows). There is no calcification of the ligaments.

which regions the flattening of the vertebral bodies may amount to actual collapse, whereby the superjacent and subjacent discs seem to come in contact with each other in the center of the vertebral body. Consequently, the intervertebral space appears almost globular, the vertebral body having a deep spoon-shaped excavation of the bone on both its upper and lower surfaces. When this collapse eventually involves all parts of the vertebral body, marginal as well as central, the latter may appear plane, but it is noteworthy that even then the adjacent interspaces may remain wide, showing that the disturbance, even if very well marked, does not necessarily impair the normal elasticity of the disc. In one case only, there was some doubt as to whether two discs were involved in the process and slightly flattened.

One may find various stages of the disease in the selfsame person and at the same time; some vertebrae, although increased in radiolucence, may show only a slight exaggeration of the normal concavity of their upper and lower borders, while other sections of the column show definite expansion of the discs, and in two or three vertebrae the changes may amount to actual collapse. Usually, the cervical spine, although definitely demineralized, shows only very slight deformities, if any; similarly, the upper half of the thoracic region and, commonly, the lower thoracic vertebrae also show very little change. On the other hand, the regions between the fifth and the eighth thoracic vertebrae, and the twelfth thoracic and the first and second lumbar vertebrae, are commonly the sites of the most profound alterations.

This statement holds true even in those very early stages of the disease in which there is not yet any definite decrease in the height of the vertebral bodies. During this period, increased concavity of the vertebral bodies is perceptible only in the middle portion of the thoracic spine and in the upper lumbar spine, while the other segments show demineralization, but no change in shape. The disease seems to progress very slowly; in two instances, reexamination after fifteen and nineteen months, respectively, revealed only very slight accentuation of the process.

Generally speaking, there are very few reactive changes in this disease. As already stated, very slight calcifications may occur in the longitudinal ligaments, or small exostoses at the anterior borders of one or two vertebrae. It is questionable, however, whether these changes are consequent upon the process in question, as they are very common in persons above fifty years of age and may be merely residues of some antecedent process. On the contrary, it is just this absence of reactive ossifications which is in such striking contrast with the high degree of alteration of the vertebral bodies; indeed, their absence is almost pathognomonic, for other rarefying processes of similar chronicity almost invariably induce large "supportive" exostoses springing from the vertebral bodies.

It is noteworthy that ossification of the costal cartilages may coexist with platyspondylia aortosclerotica, although in two cases no such incrustation was present. No opaque calculi have been seen in the abdomen, nor calcifications in other parts of the body.

Clinically, no evidence of parathyroidism was found. In one instance, a slight increase in blood cholesterol was the only biochemical alteration detected by laboratory test. In another case, the blood pressure was moderately increased (160/80), but no other significant changes were found. As previously mentioned, all bones other than the affected vertebrae were normal both clinically and roentgenographically; in particular, there was no evidence of abnormal fragility or pliability. In no case did the history suggest the presence of an avitaminosis, nor were there any symptoms or signs indicative of such a condition. There was no fever; the blood counts were normal; and there were no signs of a chronic or focal infection, nor of any involvement of the spinal cord and roots. In spite of the high degree of calcification of the abdominal aorta, none of the patients complained of abdominal discomfort, but all of them had slight circulatory weakness corresponding to a moderate degree of muscular insufficiency of the heart. No stenocardiac attacks were complained of, nor did we find in any case evidence of congestive heart failure. The peripheral arteries were not calcified, nor were there any signs of definite cerebral arteriosclerosis. Incidentally, in the presence of calcified peripheral arteries, rarefaction of the spine has not been found. All of our patients were still able to do a moderate amount of physical work and to attend to their usual occupations, such as housekeeping and office work; none of them had been subjected to any abnormal physical strain.

DISCUSSION

Systemic rarefying processes of the vertebral column are already known to occur as part of a generalized involvement of the entire skeleton, as, for example, in hyperparathyroidism, in Gaucher's disease and allied affections, and in some other cases of unknown origin. In all these conditions, widening of the intervertebral spaces, indicating expansion of the discs, is also reported. Incidentally, it should be noted that this expansion is totally different in its nature from that which underlies herniation of the nucleus pulposus into the bodies of adjacent vertebrae, for herniation occurs in the form of circumscribed protuberances which pass through the ruptured lamina cribrosa of an otherwise unchanged vertebra; whereas, in the condition mentioned, the entire disc expands because the whole of the adjacent bone has grown soft.

Over and above the changes in the spinal column, the observations on which this report is based reveal the presence of a striking and hitherto undescribed factor,—namely, a very unusual amount of calcareous deposit in the aorta, both in the thoracic and in the abdominal portions. Neither clinical nor roentgenographic examinations nor laboratory tests have thrown any light on the nature of this coexistence of aortic calcification with spinal decalcification. Are these objectively distinct phenomena really interrelated, or does the aortic disease play a causative part in the development of the spinal lesion, as, for example, by interference with the blood supply of the vertebral bodies? Nevertheless, it is to be noted that there is some correspondence in degree between the aortic lesion and the spinal lesion, at least to the extent that the most pronounced spinal lesion observed coexisted with the most marked aortic calcification, and *vice versa*. On the other hand, we have seen very marked and extensive calcification of the abdominal aorta in three patients who did not show any changes of the vertebral column, which agrees with Norlén's statement that there is no definite interrelation between arteriosclerosis and degeneration of the discs. This observation, together with the fact that some segments of the spine may escape entirely, while others show marked compression of the vertebral bodies, would seem to indicate that aortic sclerosis of this kind does not of necessity produce such changes in the spine as those described. Moreover, if there were such a causal connection between the aortic and the spinal lesions, some interference with nutrition should be visible in other parts of the skeleton, as well as in the vertebrae. The complete absence of signs of any kind indicative of metabolic disorder, especially parathyroidism, agrees with the fact that the bone lesion is strictly confined to the vertebral bodies. On the other hand, the regular coexistence of such a severe vertebral lesion with a degree of aortic calcification never before observed roentgenographically, and the constancy of the roentgenographic findings as regards localization and the aspect of individual vertebrae weigh heavily against the assumption that such correspondence is merely accidental. As long as the pathogenesis of arteriosclerosis remains obscure, the diseases associated

with it can hardly be elucidated; accordingly, we are unable to offer any consistent theoretical explanation of the process, or processes, underlying this form of platyspondylia; but the existence of other diseases or morbid conditions similarly confined to one section of the body lends some support to the old and popular belief that certain forms of disease may be localized in special regions of the body,—left or right, anterior or posterior, as the case may be. The regional distribution of many skin diseases, the contrast between central and peripheral arteriosclerosis, and the course of certain progressive nerve lesions are some examples out of many to illustrate this old conception. On reviewing observations of this nature, one is tempted to agree with our pathologist, Dr. E. Mayer, who, when first shown the material on which this report is based, closed the discussion dryly with the remark: "It seems as though these persons were diseased posteriorly!"

The disease here discussed is the converse or complement in every respect of the process to which, in a previous report[12], we gave the name of "discogenetic disease"; this is true not only as regards the obvious difference in behavior of the intervertebral discs, but also as regards the reactive response of the supporting tissues. Finally, those regions that are most commonly involved in discogenetic disease—namely, the cervical and lower lumbar—remain almost free in the process here discussed; whereas the thoracic region, which shows the most pronounced collapse in platyspondylia aortosclerotica, is invariably free in discogenetic disease. Clinically, the difference is marked as regards the complaints made by the patients themselves. Owing to the frequent involvement of the intervertebral foramina in discogenetic disease, pain and disability, due to segmental neuritis, are the chief causes of complaint; in fact, the patient's *complaint* in discogenetic disease is more marked than the objective findings. However, in platyspondylia aortosclerotica, expansion of the discs prevents narrowing of the intervertebral foramina; accordingly, neuritis was not observed under these conditions.

We suggest the name "platyspondylia aortosclerotica" (flattened vertebrae in aortic sclerosis) as a tentative abbreviation—a sort of stenographic label—which, of course, is merely descriptive.

SUMMARY

1. In six cases, the coexistence of strongly marked calcification of the thoracic and abdominal portions of the aorta with a systemic spinal disease has been observed.

2. In all these cases, the roentgenographic appearance of the spine was identical: demineralization of all the vertebral bodies, collapse of the midthoracic and upper lumbar bodies, and pronounced expansion of the intervertebral discs into the softened vertebrae.

3. Other parts of the skeleton were not involved.

4. Peripheral and cerebral arterioscleroses were not evident.

5. The apophyseal articulations were free, and the intervertebral

foramina were not affected; the longitudinal ligaments sometimes showed small calcifications.

6. Signs of metabolic disturbance or endocrine disorder were not found.

7. Except for the gradual formation of a gibbosity, the disease does not cause marked subjective symptoms.

8. The term "platyspondylia aortosclerotica" is suggested to designate this morbid entity.

REFERENCES

1. Ballin, Max: Parathyroidism in Reference to Orthopaedic Surgery. J. Bone and Joint Surg., XV, 120, Jan. 1933.
2. Baron, A., und Bársony, T.: Zentral eingedellte Wirbelkörper. (Eine eigenartige reziproke Modellierung der axialen Wirbelsäulenelemente.) Fortschr. a. d. Geb. d. Röntgenstrahlen, XXXVI, 377, 1927.
3. Bernstein, M. A.: Experimental Production of Arthritis by Artificially Produced Passive Congestion. J. Bone and Joint Surg., XV, 661, July 1933.
4. Calvé, Jacques, and Galland, Marcel: The Intervertebral Nucleus Pulposus. Its Anatomy, Its Physiology, Its Pathology. J. Bone and Joint Surg., XII, 555, July 1930.
5. Funsten, R. V.: Certain Arthritic Disturbances Associated with Parathyroidism. J. Bone and Joint Surg., XV, 112, Jan. 1933.
6. Galland, M.: Les hernies nucléaires vertébrales intraspongieuses. Bull. et Mém. Soc. de Méd. de Paris, No. 9, 275, 1930.
7. Geist, E. S.: The Intervertebral Disk. J. Am. Med. Assn., XCVI, 1676, 1931.
8. Keyes, D. C., and Compere, E. L.: The Normal and Pathological Physiology of the Nucleus Pulposus of the Intervertebral Disc. An Anatomical, Clinical, and Experimental Study. J. Bone and Joint Surg., XIV, 897, Oct. 1932.
9. Moffat, B. W.: Enlargement of the Intervertebral Disc Associated with Decalcification of the Vertebral Body: a Compensatory Hypertrophy. J. Bone and Joint Surg., XV, 679, July 1933.
10. Norlén, S.: Om Patologiska Förändringar i Intervertebraldiskerna. Hygiea, LXXXIX, 159, 1927.
11. Oppenheimer, Albert: Diseases Affecting the Intervertebral Foramina. Radiology, XXVIII, 582, 1937.
12. Oppenheimer, Albert, and Turner, E. L.: Discogenetic Disease of the Cervical Spine with Segmental Neuritis. Am. J. Roentgenol., XXXVII, 484, 1937.
13. Schmorl, G.: Ueber Knorpelknötchen an den Wirbelbandscheiben. Fortschr. a. d. Geb. d. Röntgenstrahlen, XXXVIII, 265, 1928.
14. Smith, N. R.: The Intervertebral Discs. British J. Surg., XVIII, 358, 1930–1931.
15. Turner, E. L., and Oppenheimer, Albert: A Common Lesion of the Cervical Spine Responsible for Segmental Neuritis. Ann. Int. Med., X, 427, 1936.
16. Wagoner, George, and Pendergrass, E. P.: Intrinsic Circulation of the Vertebral Body with Roentgenologic Considerations. Am. J. Roentgenol., XXVII, 818, 1932.

USE OF FASCIA LATA IN KNEE-JOINT INSTABILITY *

BY W. B. CARRELL, M.D., DALLAS, TEXAS

The author wishes to report his experience with the use of fascia lata in the treatment of knee-joint instability as follows:

1. Repair of the anterior cruciate ligament.
2. Support for hyperextension weakness.
3. Repair of the medial ligament.

REPAIR OF THE ANTERIOR CRUCIATE LIGAMENT

A fascial strip, reflected from the outer side of the thigh, is passed around the lateral condyle to enter the posterior compartment of the knee directly over the origin of the normal anterior cruciate ligament. The attachment of the fascial strip is made through a drill hole in the tibia at the point of insertion for the anterior cruciate ligament.

Technique

The entire lower extremity is prepared and, before application of the tourniquet, the strip of fascia is reflected. The incision extends from the lateral condyle along the outer side of the thigh for a distance sufficient to reflect a strip of fascia, eight inches in length and two inches in width, downward to the condyle. The base of the strip remains attached at the lower end. The incision is temporarily closed with forceps, and a sterile tourniquet is applied. Through a medial patellar incision, the joint is inspected, and any additional surgical procedure, such as removal of the meniscus, is carried out at this stage. The lateral incision is again ex-

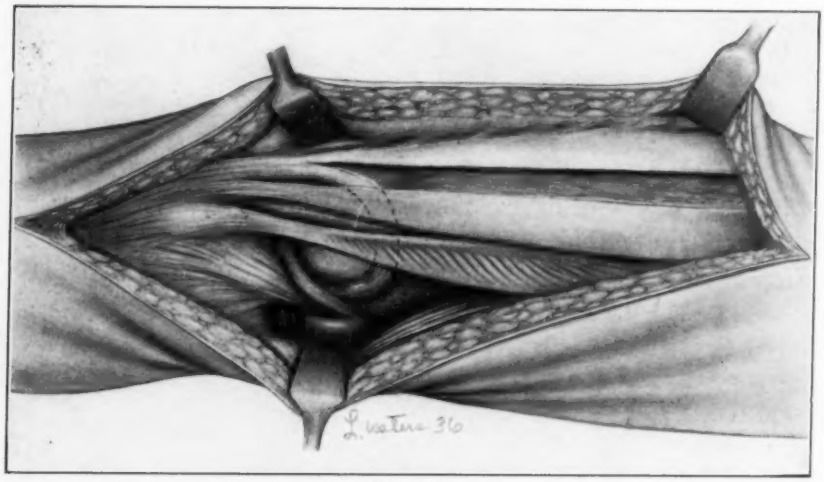

FIG. 1-A

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 15, 1936.

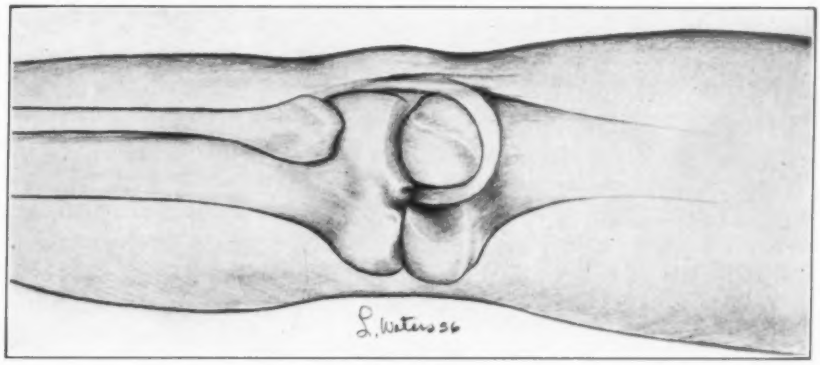

FIG. 1-B

Repair of the anterior cruciate ligament. The lateral thigh and knee are exposed, showing the fascial strip passing into the posterior compartment, directly over the origin of the normal anterior cruciate ligament.

posed, and, in the condylar area, a deeper incision is made through the vastus lateralis to reach the posterolateral surface of the femur just above the condyle. This incision is deepened, and, with a long, narrow retractor, the posterior capsule of the joint is exposed. With this in view, the operator passes a carrier directly through the anterior incision into the joint, which is made to penetrate the posterior capsule and to emerge in the lateral incision. This carrier is similar to an aneurysm needle; it has the proper curve for swinging around the condyle and a large eye to receive the fascia. The strip of fascia is threaded through the eye of the carrier and is then pulled through the knee joint. When properly placed, it passes from its base immediately deep to the femur and thence around the femur against the expanding portion of the condyle to pass over the normal attachment of the anterior cruciate ligament. A drill hole is made through the tuberosity of the tibia, starting on the medial side and emerging in the joint at the center just anterior to the tibial spine. The drilled fragments are carefully removed from the joint. The ligament is pulled through and, under firm tension with the knee at

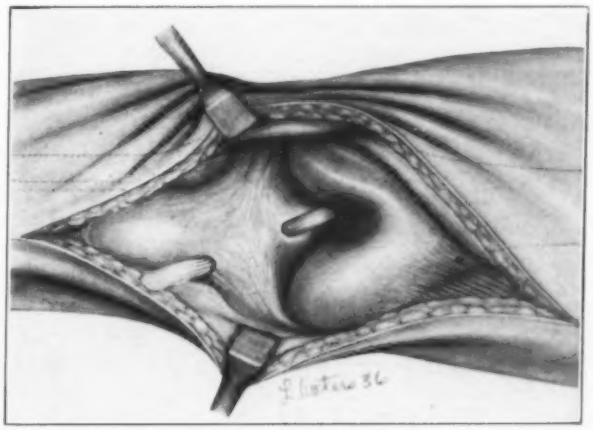

FIG. 2

Repair of the anterior cruciate ligament. The fascial strip is attached to the tibia. A longer end can be used for medial-ligament support.

170 degrees, is fastened securely with silk ligatures at the anteromedial side of the tibia. When indicated, the end is continued upward on the medial side of the knee to lend additional support to the medial ligament. The incision is closed in layers. (See Figures 1-A, 1-B, and 2.)

The knee is put up in plaster in a position of 170 degrees for four weeks. A brace is then fitted and exercises are started, with gradual extension of the leg. The brace should be worn for from sixty to ninety days. The new ligament, passing from the origin to the insertion of a normal cruciate ligament, is mechanically placed for maximum function.

This operation has been performed in the following seven cases with good results.

CASE 1. W. C. H., male, aged thirty-eight years.

Six months previous to examination, the patient had been struck on the outer side of the right leg by a truck bumper. He had grasped the front of the car and the leg had been badly twisted, due to dragging of the foot on the ground. There was no fracture, and plaster was worn for two weeks. At the end of this time, the knee was still swollen. The patient remained in bed six weeks, exercising the knee, but bearing no weight. On getting up, the knee was weak and there was a slipping sensation, but no locking.

Examination, on September 29, 1933, revealed a full range of motion, atrophy of the quadriceps, and anterior and medial displacement of the tibia on the femur as the knee was extended during weight-bearing. The patient was on crutches at this time.

A knee brace was applied, and limited use of the knee and quadriceps exercises were advised. At the end of sixty days there was no improvement.

On December 19, 1933, the knee joint was exposed, revealing normal cartilage and complete rupture of the anterior cruciate ligament. A new cruciate ligament was constructed from fascia lata by the technique described. The medial ligament was reenforced by turning the end of the fascia upward to the medial condyle.

The patient returned to his regular occupation as a traveling salesman; he drives through the country and walks freely, with no appreciable limp. He says that the injured knee is not quite as good as the other one. He has never regained full quadriceps power and has a 30-degree limitation of flexion. The result would not be good for athletic work, but is satisfactory as far as his occupation is concerned.

CASE 2. M. A. Y., female, aged eighteen years.

Ten months before admission, the patient had slipped on a marble floor and had injured the right knee. A few weeks later, the medial cartilage was removed. Four weeks later, while walking with a cane, the patient tripped and the knee was badly wrenched. The swelling returned and she was unable to use the leg for several weeks. When walking was resumed, the knee gave way, causing several falls. No locking occurred, but there was general relaxation in the joint and the patient could not discard the crutch.

Examination, on October 9, 1931, showed a relaxed knee and abnormal mobility in every direction. The tibia moved forward one inch beyond normal limits. A diagnosis of ruptured anterior cruciate and medial ligaments, following injury soon after the cartilage operation, was made.

On November 6, 1931, the joint was opened; the medial cartilage was absent, both cruciate ligaments were torn, and the ends were retracted. New medial and lateral ligaments were constructed from free strips of fascia attached to the bone above and below. In addition, fascial sutures were interwoven in the expansion of the vastus lateralis, crossing the anterior medial part of the joint. The knee was fixed in plaster for three months, followed by a brace and quadriceps exercises.

There was improvement in lateral stability and general function, but the patient could not discard the brace. Anterior posterior instability persisted. Consequently,

on April 21, 1932, an operation was performed to restore the cruciate ligaments. The posterior cruciate ligament was reformed from the biceps, according to the technique of Cubbins; the anterior cruciate, from the tensor fasciae femoris reflected in the manner described.

The knee is stable with motion from 180 to 100 degrees. The patient walks without any appreciable limp and can walk any distance without fatigue. He has difficulty with stairs, due to limited flexion.

CASE 3. M. J., female, aged twenty years.

The patient gave a history of a Neisserian infection one year previous to admission. At examination, on February 5, 1929, the left knee was found to have 20 degrees of motion (from 90 to 110 degrees) and was slightly painful. The patient used a crutch.

A posterior capsulotomy was done, which resulted in fibrous ankylosis between the femur and the tibia in a position of 165 degrees.

On October 16, 1932, an arthroplasty was performed, and a heavy mass of scar and osseous tissue was freely dissected from the posterior structure. This resulted in good motion, fair lateral stability, and poor anterior posterior stability. During weight-bearing, with the knee in a position of 200 degrees, the tibia slipped forward on the femur.

On April 19, 1934, a new anterior cruciate ligament was made, according to the technique described. Subsequent examination showed the new articulating surfaces covered with smooth fibrous tissue and the presence of clear fluid. The knee is stable with good function and motion from 185 to 120 degrees. The patient has a moderate limp and walks any distance without fatigue.

Instability in this case was due to damage of the medial and lateral soft tissues in the treatment of the flexion deformity prior to arthroplasty.

CASE 4. R. E. V., male, aged twenty-eight years.

The patient had been caught in a line shaft and had sustained multiple injuries, including several fractures. Instability of the right knee had persisted over a year.

Examination, on February 27, 1933, revealed anterior and medial rotation of the tibia on the femur, relaxation, and instability. An old fracture of the medial plateau of the tibia had united in fair position.

The joint was exposed and the cartilage was found to be intact. The anterior cruciate ligament was torn and retracted, and the medial side of the joint was relaxed. A strip of fascia lata was reflected to the condyle, thence behind and through the joint into the tibia and upward to support the relaxed medial ligament.

As a result, the patient had a full range of motion, with no appreciable limp, and returned to his former occupation.

CASE 5. L. W., male, aged twenty years.

In October 1934, during a football scrimmage, the patient had twisted the right knee severely, and in a few hours swelling and pain had occurred. There was no locking, and full extension was possible. He used crutches for three days and a cane for three weeks. He was unable to return to playing football. The knee was weak and loose, with a slipping sensation frequently during walking.

Examination, on May 25, 1935, revealed relaxation of the joint, full extension, and anterior and medial displacement of the tibia on the femur. A diagnosis of rupture of the anterior cruciate ligament was made.

At operation, the joint was exposed and the internal cartilage was removed; the anterior cruciate ligament was found to be completely ruptured. A new ligament was formed from fascia lata through the joint into the tibia; the medial ligament was not reenforced.

Good function was obtained in four months; slight medial relaxation persisted. The patient was allowed to run, but was not permitted to play football for eight months.

In this case, the fascial strip should have been cut long enough to reflect from the tibia on the medial side for reenforcing the medial ligament.

CASE 6. D. A., male, aged eighteen years.

The patient had sustained a football injury four months previous to admission. He had been unable to straighten the right knee, and there was a feeling of weakness and aching after walking. Following the injury, he had kept off the leg for four or five days. He had been walking poorly since that time.

On January 20, 1933, a diagnosis of internal-cartilage injury, with partial rupture of the anterior cruciate ligament, was made.

At operation, the joint was exposed, revealing a bucket-loop injury to the medial cartilage and complete rupture of the anterior cruciate ligament. The cartilage was removed and a new anterior cruciate ligament was made from fascia lata in the manner described. The medial ligament was not reenforced.

An excellent result was obtained, and the patient was able to engage in football and other athletic sports after eight months.

CASE 7. M. S., male, aged seventeen years.

Sixty days previous to admission, the patient had been in a car wreck, and the left knee had been badly wrenched. Swelling and disability occurred immediately. The patient was given rest in bed, with no fixation of the joint. Two weeks later he was permitted to be up on crutches, and an effort to use the knee was made. At the end of two months on crutches, the knee was relaxed and would not sustain weight. The tibia moved forward and backward and to the medial side. A diagnosis of rupture of the cruciate ligaments and of the medial ligament was made.

On August 28, 1931, exposure of the joint revealed rupture of the anterior and posterior cruciate ligaments. The torn medial cartilage was removed and the medial side of the joint was stabilized with free fascial transplants, fastened in the bone at the femur and the tibia. The knee was fixed for three months.

This operation resulted in persistent instability. The tibia moved forward and backward on the femur, and the knee function was poor. Consequently, on June 30, 1932, the cruciate ligaments were reconstructed. The posterior ligament was formed from the biceps tendon, according to the method of Cubbins. The anterior ligament was formed by reflecting a strip of fascia lata behind the condyle through the joint into the tibia, as previously described.

The result was fair; some abnormal mobility was present, and there was a 25-per-cent. disability of the knee.

This group, though small, represents severe and unusual types of injury. In most instances, the early treatment had been inadequate. Rechecking, after from one to four years following operation, gives conclusive evidence of permanency of the acquired stability.

Patients with uncomplicated cruciate-ligament injury, and even those with associated rupture of the collateral ligament, will recover with good function in most instances, if early and adequate fixation is established.

SUPPORT FOR HYPEREXTENSION WEAKNESS

A strip of fascia reflected from the outer side of the thigh, two inches wide and eight inches long, is passed between the tibia and the fibula, just below the head of the fibula, to reach the posterior compartment behind the knee joint. The strip is drawn upward in contact with the posterior capsule, passed through two drill holes in the posterior surface of the femur, and then directed downward to emerge on the anterior surface of the leg through the same compartment between the tibia and the fibula. It is attached under tension with silk ligatures.

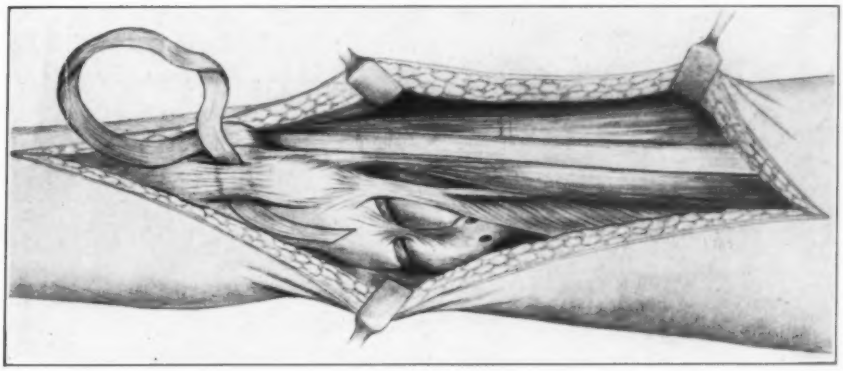

FIG. 3

Fascial strip for hyperextension. The posterior lateral exposure is used for illustration only. The popliteal muscles prevent full view in the actual operation.

Technique

A long incision is made on the lateral surface of the thigh, extending downward below the head of the fibula. A strip of the iliotibial band, two inches wide and measuring approximately eight inches above the condyle, is divided above and reflected down the thigh. On reaching its attachment on the tuberosity of the tibia, a small portion of periosteum is reflected with the fascia and for an additional inch the continuation is the fascial expansion of the leg. In crossing the joint, care is exercised to separate fascia from capsule, so that the latter may not be opened. The incision above the knee is then carried deeper, exposing the posterior surface of the femur, the condylar areas, and, in the deep inferior portion, the capsule of the knee joint. This part of the incision is the same as for capsuloplasty. Two drill holes are made in the femur at the junction of the shaft and the expanding condyle,—one at the posterolateral juncture, another well to the medial size. A medullary connection is made between the two drill holes. A drill, three-eighths of an inch in diameter, is the proper size. With the knee in flexion, a curved guide is introduced between the tibia and the fibula and made to emerge into the posterior space behind the femur. It will be necessary to incise over the end of the guide the redundant folds of capsule. Another guide, introduced from above and posteriorly, is carried through this opening to emerge between the tibia and the fibula on the anterior surface. The fascial strip is attached and

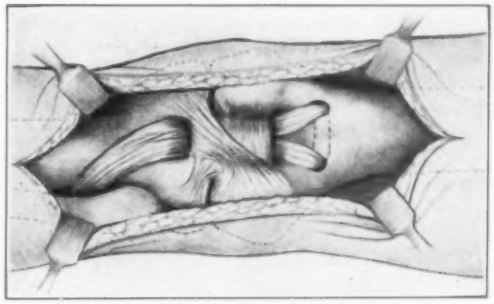

FIG. 4

Fascial strip for hyperextension. Visualization of the proper relation of the fascial strip to the posterior portion of the knee joint.

FIG. 5-A FIG. 5-B

Hyperextension deformity.

pulled through to the posterior femoral area. It is then carried through the drill holes, entering the one on the medial side and emerging through the one on the lateral side. A wire loop is used for guiding the strip through this area. The guide is then reintroduced from below upward to bring the fascial strip back, making a double structure on the posterior surface of the knee. The fascial end is secured with silk ligatures under the desired tension. The knee should be in flexion of 10 degrees more than is desired for future function. This is important, because it has been found that, with firm tension applied in a fixed position, an additional 10 degrees of stretching will occur in the progress of recovery. The leg is put up in plaster, and the position is secured for eight weeks. On removal of the plaster, a brace is fitted, and gradual extension is secured. (See Figures 3 and 4.)

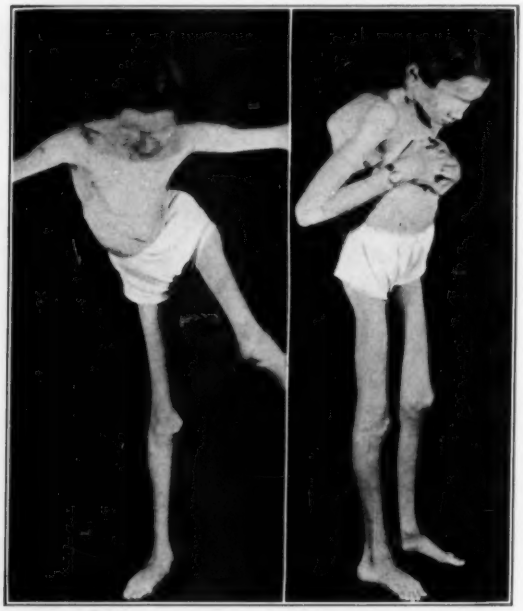

FIG. 6-A FIG. 6-B

Same patient, two years following operation.

This operation, apparently sound, has been done in twelve cases. The case with the longest postoperative period (two years) has recently been checked and the indications are that the support is adequate. (See Figures 5-A, 5-B, 6-A, and 6-B.) In no instance has there been a recurrence of hyperextension.

The deformities in these cases resulted from poliomyelitis, and other disabilities were associated. The children ranged in age between eight and fifteen years. In two cases it was necessary to wedge the knee into hyperextension of 10 degrees six months

after operation, because postoperatively the knee was placed in 10 degrees of flexion and remained tight at 180 degrees. Wedging was carried out slowly, and sufficient time has not elapsed to determine if the new position will hold.

Final reports on this series will be made in a few years. However, the author has confidence in the procedure and will continue to employ it when indicated.

REPAIR OF THE MEDIAL LIGAMENT

Most ligament injuries, even of severe grade, can be repaired satisfactorily with good fixation and conservative treatment. Extensive laceration and poor management may result in an extremely unstable joint. In this type of case it is desirable to preserve the medial fascia with its connection to the aponeurosis of the vastus medialis for the additional support on the inner side of the knee. In 1928 and 1932, in two cases the ligaments were repaired by reflecting a strip of the iliotibial band down the outer side of the thigh and passing it through a drill hole in the condyles, barely missing the supracondylar notch. The fascia, emerging just below the medial epicondyle, was reflected downward across the joint and fastened securely into the tibia and the fascia of the leg. The results were satisfactory. The final modification of the procedure, which we have done in a few cases, is simpler and as effective.

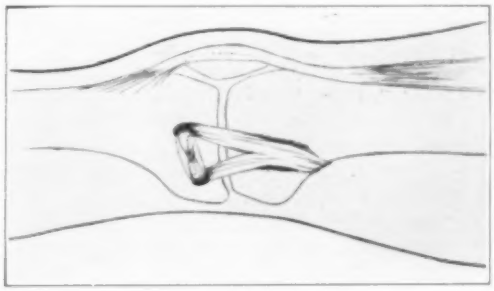

FIG. 7

Repair of the medial ligament of the knee. A strip of fascia lata emerges from the posterior surface of the femur to pass over the epicondyle for attachment on the tibia.

Technique

A strip of fascia from the iliotibial band is reflected downward to a point just above the lateral condyle. The strip should be two by eight inches. The medial side of the knee is then exposed, and, through a stab wound in the deeper tissues, a guide is passed directly behind the femur just above the condyles to emerge on the lateral side through the vastus lateralis and to secure the fascial strip. The fascia is pulled through and on the medial side is reflected forward to the center of the condyle; it is then pulled directly downward to the medial side of the tibia. On the surface of the femoral condyle, where the fascia is in contact, a channel is made by introducing a broad osteotome and lifting backward a layer of bone and fascia, permitting the fascia to come in direct contact with the freshened bone. Two drill holes are placed an inch apart on the medial

side of the tibial tuberosity. The fascia is split and each half passes through one hole and emerges at the other. The ends are secured under tension with silk ligatures. (See Figure 7.) The incisions are closed and the leg is put up in a straight position with plaster from the toes to the groin. A walking boot is attached, and the plaster is worn for eight weeks. Gradual resumption of flexion and function, with quadriceps exercises, is followed for another forty to sixty days.

One of the cases is reported because of its unusual character.

C. M., female, aged thirty years.

Eighteen months previous to admission, the patient had had an abortion with infection, complicated by suppurative arthritis of the knee. Bilateral drainage had been maintained for three months.

Examination, on June 19, 1929, showed sound ankylosis, flexion of 130 degrees, genu valgum of 20 degrees, healed three-inch scars on both sides of the knee, poor quadriceps function, and fusion of all bones.

An arthroplasty, performed on November 30, 1929, resulted in poor stability but good motion. The medial and lateral soft structures had been damaged by previous drainage, with resultant scar tissue.

On October 18, 1932, examination showed marked instability; on weight-bearing the tibia rotated forward and inward, and the patella subluxated outward. Consequently, an operation to repair the medial ligament was done. The patellar tendon was transferred to the anterior medial surface of the tibia, a bone graft (ledge of bone) was placed in the upper end of the tibia on the medial side, and a strip of fascia was reflected down the femur and passed through a drill hole, to emerge on the medial side for attachment to the tibia after crossing the joint.

As a result of this operation, the joint is stable and there is no displacement of the tibia to the medial side on weight-bearing. There is motion from 180 to 100 degrees. The patient walks without a cane with an easy gait, and she has only a slight limp.

A bone block was added in this case, because of extreme displacement. The fascial strip would probably have been adequate.

RECURRENT OR HABITUAL DISLOCATION OF THE PATELLA

A Critical Analysis of Twenty Cases*

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The twenty cases of recurrent or habitual dislocation of the patella on which this paper is based were taken from the private and service files of the Orthopaedic Services of the Hospital for Joint Diseases, New York City. There were twelve females and eight males, varying in age from seven to forty-three years: one patient was seven years old; eight were between the ages of twelve and twenty; four were between twenty-one and thirty; five were between thirty-one and thirty-nine; and two were between forty and forty-five. Two cases were bilateral and eighteen were unilateral; of the latter, the right knee was involved in nine cases and the left knee in nine.

DURATION OF ILLNESS

This period varied from one month to twenty-three years, as follows:

Period	*No. of Cases*
1 month	1
3 to 6 months	4
1 to 5 years	8
6 to 10 years	3
11 to 23 years	4
	20

RELATION OF TRAUMA

A definite history of injury was obtained in fifteen cases. In three of the remaining five cases, the history of trauma was indirect. In one of these the roentgenograms revealed Pellegrini-Stieda disease; another evidenced a marked synovitis of the affected knee; while the third was a case of Legg-Calvé-Perthes disease of the opposite hip, in which a brace had been worn for three years and abnormal stresses had been required on the opposite side,—*i.e.*, the side of the affected knee.

Of this group of eighteen cases in which trauma was directly or indirectly a factor, seventeen were unilateral and one was bilateral. In the remaining two cases, there were definite evidences of congenital anomalies, with deficiency of the lateral femoral condyle, genu valgum, and an underdeveloped, laterally displaced, and upward-riding patella.

Of the fifteen patients with a definite history of trauma, eight had had an acute, painful dislocation initially, requiring reduction and immobilization. In none of these cases had there been preceding symptoms, but weakness and disability had existed thereafter. Only two of these patients presented underlying congenital or anatomical defects.

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In the remaining seven patients, the injury was milder and without acute disability. All of these patients had had previous symptoms of weakness and instability. Six of them had some underlying defect such as genu valgum, a deficient lateral femoral condyle or intercondylar sulcus, and an underdeveloped and laterally displaced patella, usually present bilaterally.

In the traumatic group of fifteen cases, there were four cases of a torn medial meniscus: in two cases, the medial meniscus was removed at the time of reconstruction of the dislocated patella; in one, one year prior to the plastic procedure, without relief of symptoms; and in the fourth, three months after the repair, because of persistent complaints. An abnormally loose medial meniscus was also removed in one case at the time of reposition of the patella.

There was one instance of concomitant osteochondritis dissecans and one of synovial osteochondromatosis.

The injury in these cases usually consisted of a fall with indirect trauma to the knee. Direct injury occurred in but one case. In three cases, the trauma was a mere twist of the knee, during an attempt to lift a load.

SYMPTOMS

The following symptoms were observed:

Symptoms	*No. of Cases*
Weakness of the affected knee	20
Sensation of the knee's giving way	17
Lateral slipping of the patella, especially with the knee flexed	17
Pain, swelling, tenderness, and a limp	7
Definite history of "locking" of the knee. (The number of recurrent attacks, in all of which reduction was possible, varied from one to six.)	6

PHYSICAL FINDINGS

Physical examination revealed the following abnormalities:

Abnormality		*No. of Cases*
Outward displacement of the patella, exaggerated by knee flexion		20
Genu valgum		7
Unilateral, each with definite history of trauma	5	
Bilateral, one with history of trauma	2	
Underdeveloped patella		7
Diminution in range of motion		5
Diminished prominence of the lateral femoral condyle		3
Lateral instability of the knee		2
Palpable foreign body		1

ROENTGENOGRAPHIC FINDINGS

Roentgenographic examination disclosed the following abnormalities:

Abnormality	*No. of Cases*
Outward displacement of the patella	20
Underdeveloped patella	11
Fracture of the patella	4
Underdeveloped lateral femoral condyle	3
Osteo-arthritis of the lateral femoral condyle and of the posterior surface of the patella	2
Patella bipartita	2
Bilateral	1
Unilateral	1
Patella tripartita (bilateral)	1
Fracture of the medial tibial condyle	1
Osteochondritis dissecans	1
Synovial osteochondromatosis	1
Pellegrini-Stieda disease	1

PATHOLOGICAL FINDINGS

A deficient intercondylar sulcus was noted in seven cases. Osteo-arthritis of the lateral femoral condyle and of the posterior patellar surface, with erosion and fibrillation of the cartilage, was present in four cases.

There was a frank tear of the medial meniscus in one case, a diseased and fibrillated medial meniscus in another, and an abnormally loose medial meniscus in a third. It is opportune to note once again that a torn medial meniscus had been removed in one case one year prior to, and in another three months following, the repair of the patellar displacement.

Fracture of the patella was noted in four cases; in three of these, the medial patellar retinaculum was also torn.

Free bone fragments were present in one case of synovial osteochondromatosis, in one case of osteochondritis dissecans, and in one case of fracture of the medial tibial condyle.

An abnormal transverse band was present, bilaterally, between the lateral femoral condyle and the patella in one case, which maintained the lateral dislocation until it was sectioned.

An organized blood clot was found in the knee joint in one case; while in another there was a hemangioma of the soft tissues anterior to the knee joint, bearing no relation to the patellar displacement.

A congested postpatellar fat pad was partially resected in one case.

TREATMENT

The treatment was operative in every case.

The Goldthwait procedure was utilized in five cases, in two of these with the additional reefing of the internal capsule. By this operation the patellar tendon and the tibial tubercle are exposed through a five-inch incision. The former is then split into a medial and a lateral half and the outer portion is freed from its attachment to the tubercle, drawn inward beneath the intact inner half, and sutured to the periosteum, together with the expansion of the sartorius tendon, on the inner side of the anterior surface of the tibia. The only variation from this technique consisted in

the removal of a small segment of the tibial tubercle along with the lateral half of the patellar tendon, to be mortised into a trough made at the new site of insertion, so that a firm osseous attachment might be secured.

The Albee operation was performed in six cases. In this procedure, through a semilunar incision over the outer border of the patella, extending from the tibial tubercle to a point above the lateral femoral condyle, the condyle is exposed, osteotomized on its lateral surface, one-half to three-quarters of an inch behind the anterior surface, and elevated to a plane above that of the medial femoral condyle by producing a greenstick fracture near the intercondylar groove. The position of this fragment is maintained by a wedge-shaped segment of bone removed from the tibial crest and fixed *in situ* with dowel pins. In two of these cases, this procedure was combined with medial and downward transplantation of the tibial tubercle and its attached patellar tendon.

In our cases, fracture at the lateral femoral condyle was often not a greenstick fracture, but a complete fracture, yet this did not vitiate the good end results. Roentgenograms, taken several years postoperatively in some of these cases, failed to reveal any incongruity of the articular surfaces.

Medial and downward displacement of the tibial tubercle was performed, along with reefing of the relaxed internal capsule, in three cases.

In a severe bilateral case (N. D.), probably of congenital origin, an original modification was devised and employed by Dr. Leo Mayer. A twelve-inch incision, in the shape of a hockey stick, was made with the long arm on the external aspect of the thigh and the lower portion of the incision corresponding to the patellar tendon. The capsule lateral to the patella was incised vertically for a distance of four inches, and then the synovia of the joint itself was incised, allowing reduction of the displaced patella. The patellar tendon was cut away from its attachment, together with a small segment of the tibial tubercle, thus allowing free inspection of the interior of the joint, and was transplanted medially and downward, mortised snugly into its new bed, and surrounded with numerous bone chips. On the right side, a torn medial meniscus was removed; while on the left, an abnormally loose medial meniscus was extirpated through a separate three-inch incision at the inner portion of the joint. The next step consisted of reefing of all the structures on the internal aspect of the joint by overlapping first the synovial layer and then the capsule by a series of three overlapping fascial sutures, the first two by interrupted mattress sutures and the last by a continuous stitch. The final step was the covering of the resultant gap in the external portion of the joint by a flap of fascia lata, two inches wide and six inches long, dissected from the outer aspect of the thigh, turned on itself, and fastened in place with No. 1 chromic catgut. This procedure was performed on each side, with an interval of one month between operations, and was repeated more effectively on the right side in four months.

In one case, medial and downward transplantation of the tibial

tubercle was combined by Dr. Mayer with the recently described Ober fasciaplasty. The Ober procedure consists of: the liberation of a strip of fascia lata, six inches long and one-half an inch wide, from the outer aspect of the thigh, the lower end being left attached; the division of abnormal bands of tissue stretching between the lateral surface of the patella and the lateral deep structures and intermuscular septum; and the passage of this fascial strip beneath the patellar aponeurosis and through a tunnel on the medial aspect of the tibia in the region of the hamstring insertion, the latter being made through a separate three-inch incision. This strip effectively maintains the reduction. In this case (E. L.), a fascial strip, two and one-half inches wide and four inches long, following the medial and downward displacement of the tibial tubercle, was removed from the outer aspect of the thigh, its inferior attachment being preserved, and was brought over the lower end of the patella and sutured to the new site of insertion of the tibial tubercle, thus reenforcing it.

It is questionable to whom priority relative to the introduction of the complete transplantation of the tibial tubercle is due. This procedure has been utilized by Albee and others, but Tubby, in 1912, noted its use "by numerous surgeons" in his book entitled "Deformities".

In one case, the dislocation of the patella was reduced and the relaxed internal capsule simply reefed, maintaining the patella after reduction in its normal position.

In three cases, the dislocation of the patella was reduced and the accompanying torn medial patellar retinaculum was repaired,—in one case by simple interrupted and continuous chromic sutures; in the other two, by a reconstruction of the medial patellofemoral ligament with fascia lata. The latter procedure was performed in both cases by Dr. Henry Milch. Briefly, through a medial four-inch incision, the degenerated fibers at the insertion of the vastus medialis, the hiatus in the patellar retinaculum on the medial side of the knee joint, and the frayed transverse fibers of the patellofemoral ligament were noted. In both cases healing longitudinal fractures of the patellae were also observed. In one case (E. T.), a congested postpatellar fat pad was partially resected. A strip of fascia lata, a quarter of an inch wide and ten inches long, was removed with a fascial stripper from the outer aspect of the thigh, and this was run through a coronal drill hole in the patella, including both fracture fragments, thence through a hole in the medial femoral condyle in the region of the adductor tubercle. The patella was forced medially, so that when the fascial graft was sutured securely to itself, the patella held firmly to the medial side. The leaves of the torn patellar retinaculum and the patellar periosteal flap, previously elevated, were then imbricated one above the other.

This method closely simulates the operation described by Gallie and Le Mesurier, who also used a strip of fascia lata, run through two transverse drill holes in the patella and corresponding drill holes at the inner condyle of the femur, and sutured tautly to itself with the patella displaced medially. Soutter pointed out that, whereas the relationship of the

TABLE I

ANALYSIS OF TWENTY CASES OF RECURRENT OR HABITUAL DISLOCATION OF THE PATELLA

Patient	Age (*Years*)	Duration of Symptoms	Side Affected	Operative Procedure	Additional Surgery	Duration of Follow-Up	End Results
J. Z.	12	4 years	Left	Goldthwait		14 months	Excellent *
E. S.	19	6 years	Right	Goldthwait		4 months	Out of plaster 1 month. Position of patella, normal. Extension, 180°; flexion, 110°. X-ray shows firm union of graft.
A. H.	18	14 years	Left	Goldthwait	Torn medial meniscus removed 1 year previously	1 year	Slight quadriceps weakness. Active extension, 160°; passive extension, 180°. Position of patella, normal.
H. B.	39	20 years	Right	Goldthwait and reefing of internal capsule	Mass in quadriceps pouch removed 1 year previously (osteochondritis dissecans)	3 years	Slight tendency for lateral luxation of the patella. Extension to 175°; flexion to 100°. Crepitation, pain, and stiffness.
A. B.	25	5 months	Right	Goldthwait and reefing of internal capsule	Medial meniscus removed 3 months later	2 years. Last seen in 1929.	Very good. Position of patella, normal. Complete extension; flexion to 90°. Palpable crepitus, but knee painless.
M. S.	22	6 years	Left	Albee		7 years	Excellent
P. B.	7	3 years	Right	Albee		8 years	Excellent
E. D.	19	1 month	Left	Albee		9 years	Excellent
H. H.	16	2 years	Right	Albee	Manipulation 8 weeks after operation	4 years. Last seen in 1930.	Excellent. Slight periarticular swelling.
C. M.	19	4 years	Left	Albee and transplantation of tibial tubercle	Diseased medial meniscus removed. Manipulation 6 months after operation.	9 months	Excellent
J. T.	19	18 months	Both	Albee and transplantation of tibial tubercle. Left, 1 month following right.	Severance of abnormal transverse bands	14 months	Bilateral quadriceps weakness, but complete passive extension. Left knee shows some lateral instability. Partial recurrence of lateral displacement of both patellae. Patient feels that knees are "stronger".

N. D.	43	23 years. Acute signs, 1 month.	Both	Transplantation of tibial tubercle; reefing of internal capsule and plastic repair of external capsule (Mayer)	Torn medial meniscus on right removed. Left side repaired 1 month later with removal of an abnormally loose medial meniscus. Repair repeated more effectively on right in 4 months.	19 months	Excellent on both sides
C. V.	40	16 years	Left	Transplantation of tibial tubercle and reefing of internal capsule	Preceded by supracondylar osteotomy for severe knock-knee, with medial rotation of the lower fragment	3 years	Very good. Complete extension; flexion to 90°.
E. F.	23	10 years	Right	Transplantation of tibial tubercle and reefing of internal capsule	Removal of joint mice (synovial osteochondromatosis). Manipulation 5 months after operation.	2 years and 6 months	Excellent
E. D.	27	1 year	Left	Transplantation of tibial tubercle and reefing of internal capsule	Bone fragment from fractured medial tibial condyle removed	5 years	Excellent
E. L.	37	2 years	Right	Transplantation of tibial tubercle and Ober fasciaplasty		8 months	Excellent
M. R.	33	6 months	Right	Reduction of dislocation of patella and reefing of internal capsule	Fibrillated medial meniscus removed (organized clot in knee joint)	5 months	Excellent
H. H.	33	3 months	Right	Reduction of dislocation of patella and plastic repair of torn medial patellar retinaculum by reconstruction of medial patellofemoral ligament		2 years	Excellent
E. T.	31	3 years	Left	Reduction of dislocation of patella and plastic repair of torn medial patellar retinaculum by reconstruction of medial patellofemoral ligament	Partial resection of postpatellar fat pad	2 years	Excellent
M. B.	18	6 months	Left	Reduction of dislocation of patella and repair of torn medial patellar retinaculum by simple chromic sutures		1 year	Excellent

*An excellent result implies a painless knee, with normal restoration of the position of the patella and a range of motion from complete extension to complete or almost complete flexion.

patella to the femur is constantly changing, thus throwing much strain on the fascial ligament, the relationship of the patella to the tibia is constant, and he modified the procedure described by anchoring the patella to the medial aspect of the upper end of the tibia.

The correction of the laterally dislocated patella was performed as a *secondary* procedure in two cases, where operations performed one year previously—the removal of a mass in the quadriceps pouch in one case and of the medial meniscus in the other—had failed to relieve symptoms. In five cases, the plastic repair was *followed* by secondary procedures,—the removal of an undiagnosed torn medial meniscus in one case three months later, a more efficient repair of the laterally dislocated patella in one case, and manipulations to increase the range of flexion in three cases.

Postoperative care consisted of immobilization in a plaster splint, a circular plaster bandage, or a brace (two cases) for from six to eight weeks, if the bone had been operated on, or for from two to three weeks if only the soft tissues had been repaired, followed by active mobilization, physiotherapy, and exercises.

The only complication was a case of tourniquet paralysis of two months' duration, with resultant foot-drop.

END RESULTS

Follow-up observation of the twenty patients varied from four months to nine years. Many have been recently examined, a few have been corresponded with. Three patients could not be contacted, but their follow-up records were sufficiently complete to indicate the end results.

In only two cases might the end results be considered unsatisfactory. In fifteen cases the results were excellent, the position of the patella was again normal, the range of motion was complete and painless, and the function of the knee was normal.

In one case (E. S.), operated on only recently (November 1936), the position of the patella is excellent, with a range of motion from complete extension to almost a right angle, despite the removal of plaster fixation but a few weeks ago (February 1937).

In the remaining two cases, the position of the patella is normal, and the stability of the knee is excellent, with painless motion and complete extension. Flexion is limited to 90 degrees, due to slight contracture of the quadriceps and the patellar tendon. Neither patient has attended the Clinic with regularity for postoperative physiotherapy, and it is felt that by more sincere cooperation these patients might well have enjoyed perfect results.

Of the two cases in which less satisfactory results were obtained, one was bilateral, probably of the congenital type, in which an Albee procedure and transplantation of the tibial tubercle had been combined. There is partial recurrence of the deformity, yet the patient feels that the knees are "stronger", and she is satisfied with the result. She no longer is subject to the repeated falls that she experienced prior to the operation.

In the other case, of traumatic origin, a Goldthwait procedure had been combined with a reefing of the internal capsule. There is slight recurrence of the lateral patellar luxation, some limitation of flexion and extension, slight pain, and crepitation in the involved knee. Many of these disabilities and symptoms might well be attributed to a concomitant osteochondritis dissecans noted at the time of operation.

CONCLUSIONS

The traumatic factor plays a prominent rôle in this condition. Two types of cases are noted: (1) the previously asymptomatic knee upon which has been imposed direct or indirect trauma, moderate or severe, and in which anatomical anomalies play little part; (2) the knee in which congenital or anatomical defects are prominent, with preexisting mild symptoms becoming aggravated by injury.

Associated injury to the intra-articular, capsular, and periarticular structures of the knee must be anticipated and adequately cared for at the same time as the plastic repair of the displaced patella, if complete relief is to be obtained and irremediable secondary changes are to be avoided.

Excellent results have been obtained in the main, irrespective of the type of operative manoeuver employed. The less satisfactory results do not reflect adversely, with consistency, on any one method.

The trend seems to favor the simpler extra-articular procedures which have proved so mechanically efficient, especially the medial and downward transplantation of the tibial tubercle, in whole, or in part as in the Goldthwait operation, and its attached patellar tendon, combining this, as may seem necessary, with medial capsulorrhaphy or a fasciaplasty of the Ober type.

However, the indications for the type of procedure or variation to be employed, depend entirely upon the nature of the individual case—whether it be of the congenital or of the pure traumatic type—and the associated pathological conditions present.

The Albee procedure is expressly indicated in those cases in which there is congenital deficiency of the lateral femoral condyle and the intercondylar sulcus.

An associated severe genu valgum must be corrected initially—for example, by supracondylar osteotomy—prior to any corrective measures on the patella itself. As in Case C. V., the osteotomy is combined with medial rotation of the lower fragment to bring the lateral femoral condyle forward, a procedure devised by Graser.

A marked hiatus in the lateral capsule, following the patellar reduction, may require such a plastic repair as was performed by Dr. Mayer in his case.

Finally, severe associated tears of the medial patellar retinaculum and patellofemoral ligament, as in some traumatic cases, require coincident plastic repair. This underlying pathological process must be borne in mind in every *acute* traumatic case, even after successful closed reduc-

tion, and the danger of recurrent luxation must be anticipated. In the case where reduction is impossible, open correction is essential, and the tears should be repaired by several layers of interrupted mattress and continuous chromic catgut sutures. This was done in the case of one patient, F. C., aged twenty-five, not included in this series, who dislocated the right patella five days prior to reduction.

The writer wishes to express his appreciation to Dr. Leo Mayer, Dr. Samuel Kleinberg, Dr. Harry Finkelstein, and Dr. S. A. Jahss for the unrestricted use of records from their respective Services at the Hospital for Joint Diseases. He is indebted to Dr. Henry Milch for permission to present his interesting cases.

REFERENCES

Albee, F. H.: Orthopedic and Reconstruction Surgery. Philadelphia, W. B. Saunders Co., 1919.

Gallie, W. E., and Le Mesurier, A. B.: Habitual Dislocation of the Patella. J. Bone and Joint Surg., VI, 575, July 1924.

Goldthwait, J. E.: Slipping or Recurrent Dislocation of the Patella. With the Report of Eleven Cases. Boston Med. and Surg. J., CL, 169, 1904.

Graser, E.: Behandlung der Luxatio patellae inveterata durch Osteotomie am Femur mit Drehung der Epiphyse. Zentralbl. f. Chir., XXXI, 169, 1904.

Ober, F. R.: Slipping Patella or Recurrent Dislocation of the Patella. J. Bone and Joint Surg., XVII, 774, July 1935.

Tubby, A. H. Deformities. A Treatise on Orthopaedic Surgery. Ed. 2, Vol. II. London, Macmillan & Co., 1912.

SUBCUTANEOUS SURGERY IN THE DISLOCATED HIP *

BY P. M. GIRARD, M.D., DALLAS, TEXAS

Recent reports [1,2] in the literature dealing with end results in congenital dislocation of the hip lead one to the opinion that, even though such a dislocation is reduced early, either by closed or by open methods, quite frequently poor results are observed when the patient grows older.

When closed reduction is done, there is a wadding up of that portion of the capsule between the hour-glass contraction and the acetabular rim into the acetabulum, anterior to the head.[4] (See Figure 2.) This produces irregular pressure upon the head from folds of the tough, firm capsule and prevents the head from sinking deep into the acetabular cavity. Under these circumstances, the rim of the acetabulum also produces pressure upon the head. Open reduction, with release of the hour-glass contraction, has not proved to be the solution of this problem, because of the disturbance in circulation about the joint and the inevitable formation of excessive scar tissue, which always produces shortening and tightening of the capsule and adjacent muscles. This produces varying degrees of stiffness of the hip joint with poor end results.

In an attempt to circumvent the above objections to closed and open reduction methods, subcutaneous section of the hour-glass contraction was done first in 1935. This procedure has now been done in eleven cases, and has been successful in all but three,—one thirteen-year-old girl, one ten-year-old girl, and one patient with a large bifurcated femoral head.

TECHNIQUE

An incision, approximately two centimeters long, is made just above and slightly anterior to the greater trochanter and parallel to it. The fibers of the gluteus maximus are separated by blunt dissection with artery forceps. (See Figure 3-A.) The anterior portion of the capsule is punctured, and the hour-glass contraction is palpated with the end of the forceps. The dense contracted portion of the capsule is grasped by the Ochsner forceps. A scalpel is passed along side of the forceps, and the constriction is cut, three slits being made. (See Figure 3-B.) The dislocated head is then reduced by manipulation and held by a plaster cast. The hour-glass contraction slips over the head, permitting the head to enter deeply into the smooth acetabular cavity. (See Figure 4.)

If the head cannot be reduced without undue stress and strain, subcutaneous section of the adductor tendons is done, and the manipulation is again attempted. If this manoeuver is unsuccessful, a subcutaneous section of the muscles attached to the anterior superior spine is next done. Passing a cartilage knife subperiosteally around the greater trochanter

* Read before the Orthopaedic Section of the Southern Medical Association, Baltimore, Maryland, November 18, 1936.

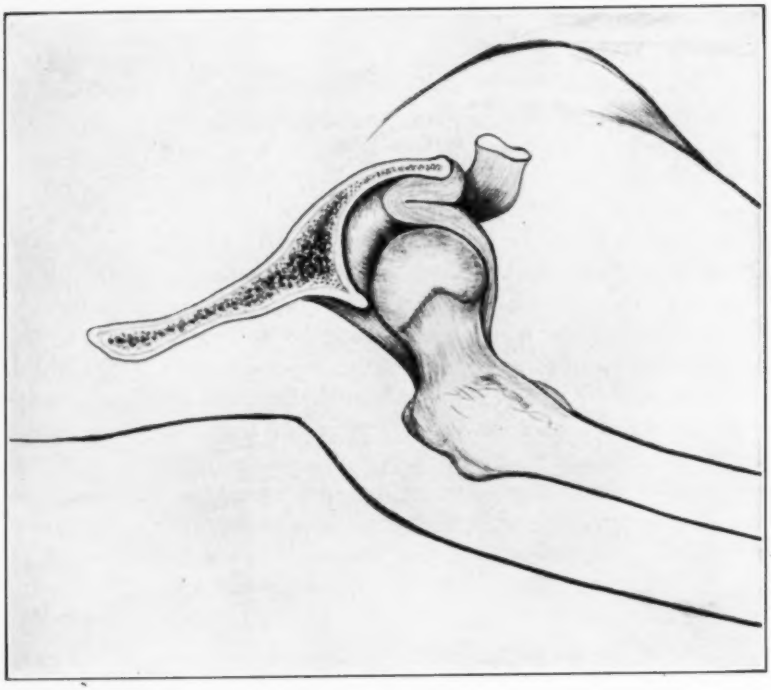

FIG. 2

Diagram showing the folding of the hour-glass contraction into the acetabulum when closed reduction is done.

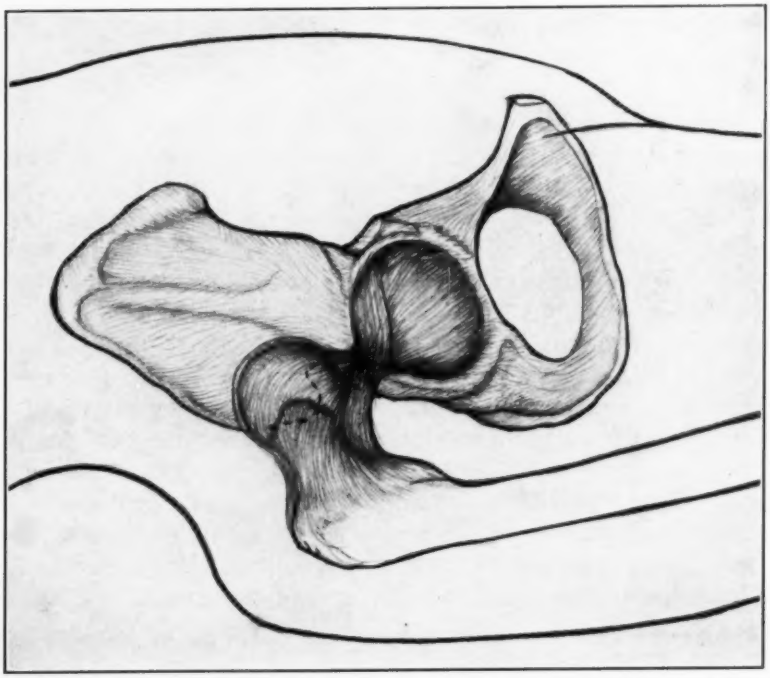

FIG. 1

Diagram of an hour-glass contraction in the capsule of a congenitally dislocated hip.

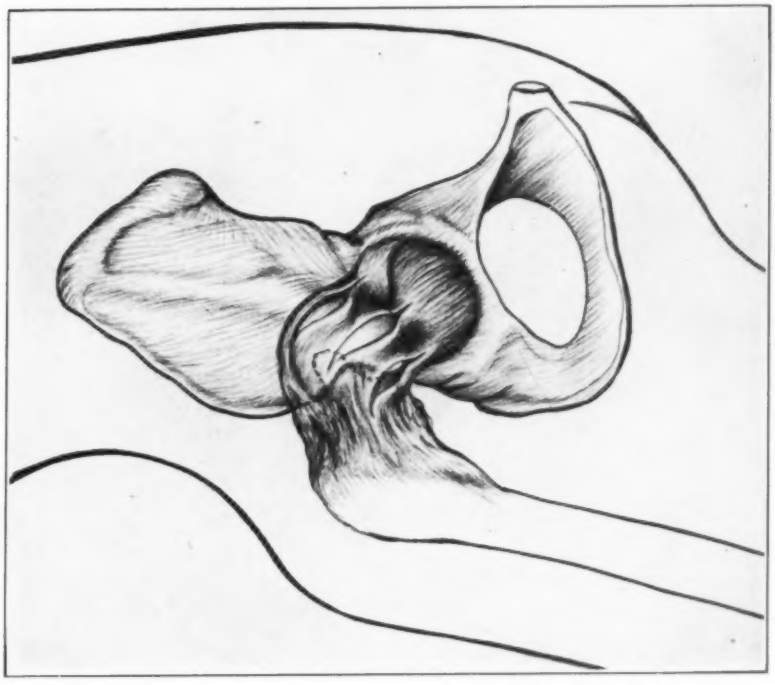

FIG. 3-B

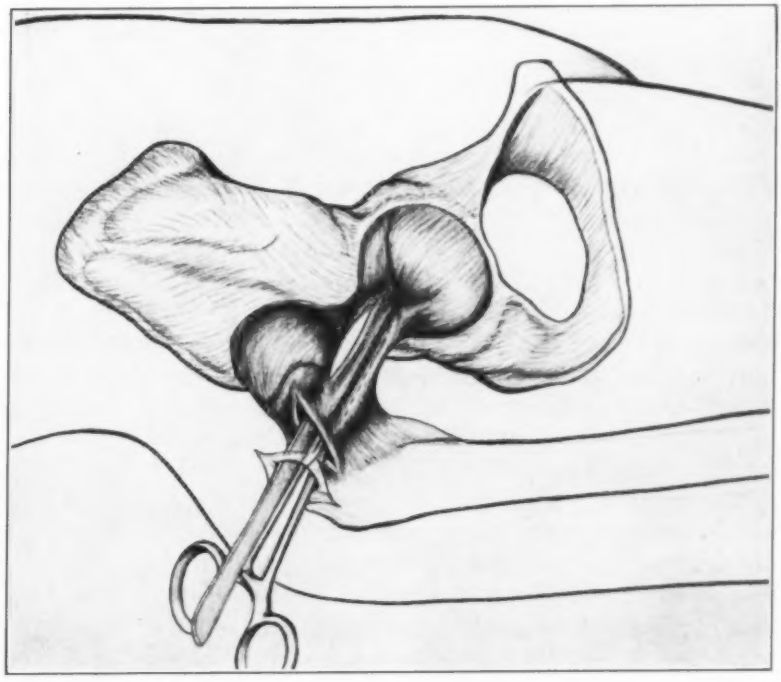

FIG. 3-A

Subcutaneous sectioning of the hour-glass contraction.

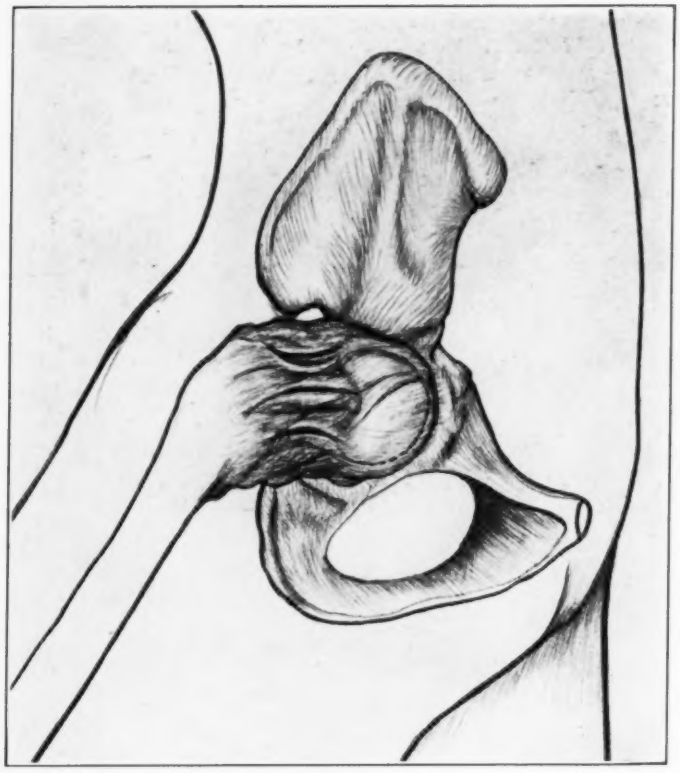

FIG. 4

The hour-glass contraction slips over the head as reduction is accomplished. This permits the head to enter deeply into the smooth acetabular cavity.

releases the glutei. This procedure is done subcutaneously through the original incision. If a third attempt at reduction fails, a Kirschner wire is passed through the condyles of the femur, and heavy skeletal traction is applied over a Braun-type splint, elevating the foot of the bed for additional countertraction. (See Figure 5.)

In from ten to twenty days, roentgenographic examination usually shows the head reduced or resting on the rim of the acetabular cavity. (See Figures 6-A, 6-B, and 6-C.) Medial traction, obtained by passing a band around the upper third of the leg, may accomplish reduction. In one case a gentle manipulation was done under gas anaesthesia, and reduction was accomplished at this stage.

After reduction, the hip is held in the abduction position in a cast for three months. Following the removal of this first cast, the hip is brought down to a 45-degree position and held by a single hip spica, extending from the ribs to the knee; incorporated in the cast is a single-bar, knee-joint, caliper brace. (See Figures 7, 8-A, and 8-B.) The purpose of the brace is to prevent fracture. In this apparatus weight-bearing is allowed.

A remarkable finding in these cases has been the relatively free motion (45 to 75 degrees) present in the hips when the first cast is removed three months after reduction. When the position is considered unstable, a subcutaneous shelf operation may be done at the time of reduction or later. The technique followed in doing this operation is that reported by Spitzy.[3]

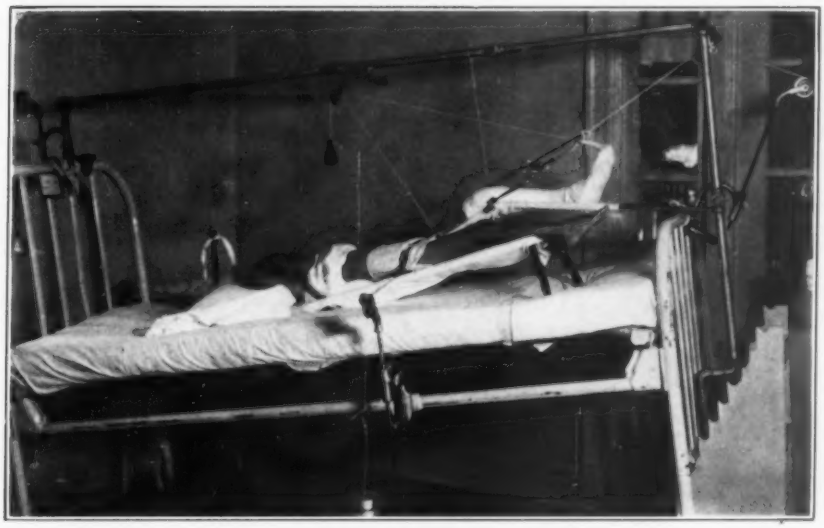

FIG. 5

Kirschner-wire traction and medial traction after subcutaneous release at the hip.

CASE REPORTS

CASE 1. J. B., male, six years of age, with congenital dislocation of both hips.

In January 1936, subcutaneous section of the hour-glass contraction of the capsule of one hip, together with subcutaneous section of the adductors, was done, but it was impossible to reduce the dislocation. Traction by Kirschner wire through the condyles of the femur, and traction by wire and medial traction by band around the thigh for eighteen days resulted in automatic reduction.

The patient is wearing a brace and has excellent motion. At a later date, similar treatment will be given the opposite hip.

CASE 2. M. L. B., female, aged four years, with congenital dislocation of the left hip.

In July 1936, subcutaneous section of the hour-glass contraction was done, but reduction was unsuccessful. Subcutaneous section of the adductors was also done, and reduction was again unsuccessful. Traction by Kirschner wire through the condyles of the femur and traction for twenty days with added medial traction resulted in automatic reduction of the head.

The patient had 45 degrees of motion when the first cast was removed. She is now walking without any apparatus. The hip is in excellent conjugation.

CASE 3. A. B. A., female, aged nine years, with congenital dislocation of the left hip.

In April 1936, subcutaneous section of the hour-glass contraction of the capsule failed to effect reduction. Section of the adductors was then done, but reduction was unsuccessful. Traction with Kirschner wire through the condyles of the femur for three weeks was also unsuccessful as far as reduction was concerned.

In May 1936, a gentle manipulation was done under gas, and the dislocation was reduced satisfactorily and easily. Ten months later, a double wing back shelf operation was done. The head was in the acetabular cavity, but was skidding upward on the markedly oblique upper acetabular rim.

CASE 4. B. L. H., female, thirteen years old, with congenital dislocation of both hips.

FIG 6-A

Case 1. Bilateral congenital dislocation of the hip.

FIG. 6-B

Case 1. Roentgenogram showing the head resting on the rim of the acetabulum under heavy skeletal traction.

FIG. 6-C

Case 1. Roentgenogram showing head reduced after medial traction was added.

Subcutaneous section of the hour-glass contraction of the right hip and manipulation failed to accomplish reduction. Section of the adductors, of the tensor fasciae latae, and of the glutei was done, and Kirschner-wire traction was applied for three weeks. This, with medial traction, was unsuccessful. Manipulation under gas was also ineffectual; therefore, open reduction was done. The head did not remain in the cavity; consequently, seven months later, an open operation, with the shelf of the right hip in position above the acetabulum, was done. At a later date, a shelf operation will be done on the left hip, with the shelf at the same level as that of the right hip.

CASE 5. H. T., male, five years of age, with congenital dislocation of the right hip.

In June 1935, subcutaneous section of the hour-glass contraction was done, resulting in immediate reduction. Reduction was accomplished prior to subcutaneous section of the capsule, but the head was not very stable. After section of the capsule, the head of the femur sank deeply into the acetabulum and was quite stable.

To date, the functional result is excellent.

CASE 6. M. W., female, aged four years, with congenital dislocation of the left hip.

In September 1935, subcutaneous section of the hour-glass contraction of the capsule brought about immediate reduction.

CASE 7. B. H., male, aged eight years, with congenital dislocation of the left hip and a congenital cleft lip and palate.

In July 1936, tonsillectomy and adenoidectomy were done in preparation for closure of the palate by a nose and throat surgeon. Subcutaneous section of the hour-glass contraction of the capsule and of the adductors resulted in immediate reduction. (All of these operative procedures were done under the same anaesthetic.)

The patient at present is in a walking apparatus. Before this apparatus was applied, there was motion in the hip amounting to 50 degrees.

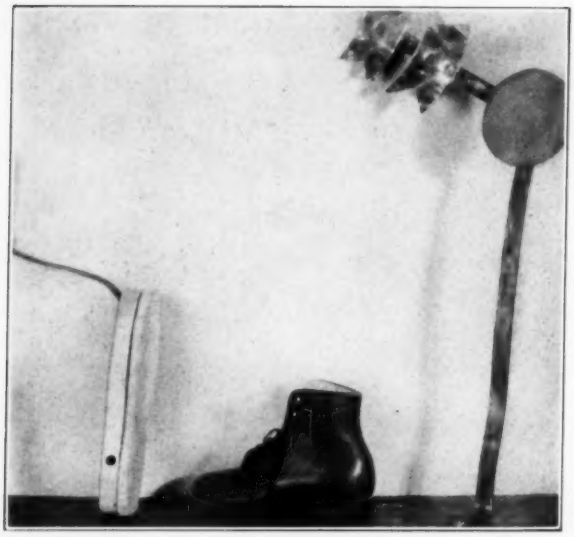

FIG. 7

Showing brace for the prevention of fracture. Foot rest for bed wear.

FIG. 8-A FIG. 8-B

Cases 7 and 8. The patients are wearing abduction plasters with braces incorporated. This apparatus is worn for three months.

CASE 8. D. S., male, five years old, with congenital dislocation of the left hip.

In June 1935, open reduction was done after an attempted subcutaneous section of the hour-glass contraction failed. Open inspection revealed a large, partially bifurcated head of the femur which was too large to enter the acetabulum. The size of the head was decreased by removing some of the wide portions of the head, and reduction of the dislocation was accomplished.

In September 1936, the head was again subluxated. The patient had suffered a fracture in the upper end of the tibia with malposition. An osteotomy was done through the old fracture site to correct alignment of the tibia, and a graft was removed from the upper half of the tibia for a subcutaneous shelf over the subluxating hip.

Examination on May 5, 1937 showed that the left hip skidded upward slightly, but was stable when the patient walked.

CASE 9. P. J. F., female, aged one and one-half years, with multiple congenital anomalies: bilateral club-hand and club-foot, flexion of the wrists, and bilateral dislocation of the hip.

On January 11, 1937, subcutaneous release of the hour-glass contraction of both hips resulted in immediate reduction.

The patient is still under observation in plaster fixation, with the hips in good position.

CASE 10. T. E. C., male, one and one-half years of age, with multiple congenital

deformities: a rudimentary right foot, deformity of the left leg due to amniotic-band contraction, left club-foot, spina bifida occulta at the fifth lumbar vertebra, and dislocation of the right hip.

On February 19, 1937, an unsuccessful attempt to reduce the dislocation by manipulation was made. Subcutaneous release of the hour-glass contraction resulted in immediate reduction.

The patient is still in plaster fixation.

CASE 11. E. K., female, aged ten years, with congenital dislocation of the right hip. No treatment had been given.

On April 16, 1937, subcutaneous release of the hour-glass contraction, of the adductors, of the tensor fasciae latae, and of the glutei at the trochanter was done. Traction by Kirschner wire through the condyles of the femur with lateral traction by band over the greater trochanter was applied for three weeks.

On May 7, 1937, attempted manipulation was unsuccessful, and the head of the femur was still above the rim of the acetabulum. The hip was fixed in plaster, and a shelf operation will be done later.

COMMENT

In cases of congenital dislocation of the hip, a subcutaneous section of the hour-glass contraction of the capsule described affords release of the contraction with a minimum of surgery. Both hips may be operated upon simultaneously by this method. Obviously, no end results can as yet be reported.

REFERENCES

1. GILL, A. B.: An Evaluation of Present-Day Methods of Dealing with Congenital Dislocation of the Hip. J. Bone and Joint Surg., XVIII, 487, Apr. 1936.
2. HEYMAN, C. H.: Late Results of Treatment of Congenital Dislocation of the Hip. J. Am. Med. Assn., CVI, 11, 1936.
3. SPITZY, HANS: Künstliche Pfannendachbildung. Benützung von Knochenbolzen zur temporären Fixation. Ztschr. f. orthop. Chir., XLIII, 284, 1922–1924.
   Dauerresultate nach künstlicher Pfannendachbildung. Zentralbl. f. Chir., LV, 1282, 1928.
4. STEWART, S. F.: The Physiological Treatment of Congenital Dislocation of the Hip. J. Bone and Joint Surg., XVII, 11, Jan. 1935.

THE IMPORTANCE OF EARLY DIAGNOSIS IN THE TREATMENT OF SLIPPING FEMORAL EPIPHYSIS *

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From the Hospital for Joint Diseases, New York City

The author's thesis in this paper is simple and can be stated briefly. After ten years' study of slipping femoral epiphysis, characterized by numerous disasters due to ignorance, we of the Hospital for Joint Diseases realize that the all-important factor in successful treatment is early recognition. We do not know the cause of epiphysiolysis, nor do we understand the early pathological changes in the region of the epiphyseal plate which make displacement possible, but we do know with certainty the characteristic symptoms and the roentgenographic appearance of the earliest stages of this condition. It is early recognition of this so-called "preslipping" stage which makes successful treatment comparatively easy. Unfortunately, many orthopaedic surgeons and roentgenologists do not appreciate the significance of these early signs, or, if they do make the correct diagnosis, they fail to understand the seriousness of the danger which these tiny red flags of pathology connote. It is quite possible for us to differ in the exact details of treatment, but we ought as a body to agree on the possibility of early diagnosis and on the necessity of early systematic treatment carried through until the danger is over,—namely, when ossification of the epiphyseal plate has occurred. The following case illustrates this very clearly.

Two years ago a girl of twelve was brought to the author for consultation. The history was typical,—a slight limp of six weeks' duration; fatigue on exertion; and very slight pain referred to the hip and thigh. There was no temperature and no malaise. The limp would disappear after a day or two of rest in bed. The physical signs also were characteristic of the early stage of this disease. There was no limp whatever, since the child had just rested in bed for a week. Flexion and extension of the hip were normal. There was, however, a definite diminution of internal rotation best demonstrated when the thigh was flexed to 90 degrees. This amounted to a loss of 20 degrees as compared with the normal side. There was also a slight limitation of abduction, but no limitation whatever of adduction. The roentgenogram showed the typical changes which will be described later. It was the writer's belief that the diagnosis could be made with certainty, yet another orthopaedic surgeon who saw the patient within a few days made light of the danger, instituted massage and exercises, and allowed the child to continue at school. The result today is a hopelessly deformed hip joint and a permanent limp.

Our own early experiences at the Hospital for Joint Diseases were equally disastrous. The case histories were characterized by numerous admissions and readmissions for one manipulation after another, all futile, followed by reconstruction operations which usually resulted in a permanent impairment of hip function.

* Read at the Annual Meeting of the American Orthopaedic Association, Lincoln, Nebraska, June 2, 1937.

FIG. 1

Early slipping of the femoral epiphysis of the right hip. Note the disappearance of the slight bulge of the right head, the slight prominence of the neck just distal to the epiphyseal line, and the slight broadening of the epiphyseal line.

Pomeranz and Sloane, in 1935, made a thorough study of 120 or more cases treated at the Hospital for Joint Diseases. They found that in those cases in which extensive displacement had occurred and fixation in the deformed position had ensued the results were bad in all but two or three instances. This was true irrespective of the nature of treatment,

Right

FIG. 2-A

Left

FIG. 2-B

Lateral views showing early slipping of the femoral epiphysis of the right hip. Note the displacement of the head in a backward and downward direction.

FIG. 3-A

FIG. 3-B

Early slipping of the femoral epiphysis which was treated by abduction in bed (case of Dr. L'Episcopo). Slipping occurred as shown in Fig. 3-B while patient was immobilized in traction.

whether manipulative or operative, and at least seven different operations had been attempted. The bad results of manipulation in the later stages were also stressed by Key in his masterly article on the subject. Pomeranz and Sloane found on the other hand that when the diagnosis was made in the early so-called preslipping stage and treatment was carried through until ossification of the epiphyseal plate had occurred the results were uniformly good.

What are these early changes? If we study roentgenograms of normal children, we note that the hemispherical head casts a bulging shadow at its junction with the upper margin of the neck. This lies just proximal to the oblique line, indicating a lighter shadow caused by the

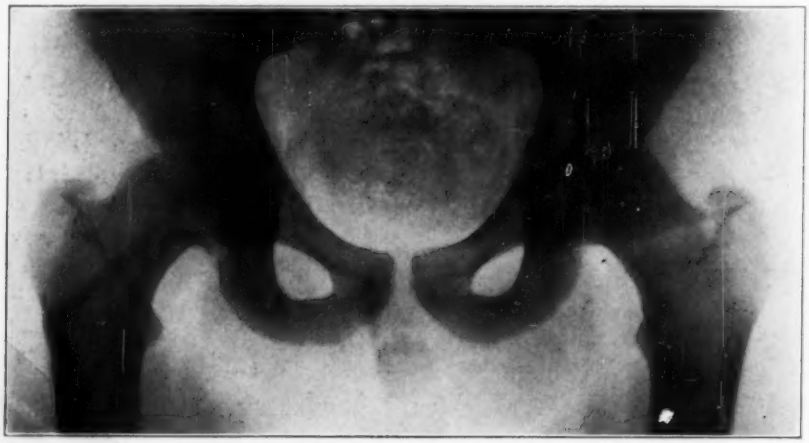

FIG. 4

Fusion of head to neck secured by implantation of a tibial bone graft.

epiphyseal plate. The first sign of slipping is the disappearance of this slight bulge and conversely the appearance of a slight prominence of the upper margin of the neck. (See Figure 1.) These roentgenographic changes are due to a combination of two motions which appear to occur synchronously,—namely, a forward displacement of the neck (an anteversion which Milch has taken pains to emphasize) and a slight downward and backward displacement of the head. Because of this, the vertical diameter of the head becomes slightly diminished. In many cases we also see a broadening of the epiphyseal line, no doubt due to the changed projection caused by the slipping. In the lateral view of the head, the downward displacement of the capital epiphysis is usually well seen. (See Figures 2-A and 2-B.)

Corresponding to these roentgenographic changes are characteristic physical signs. These have already been referred

FIG. 5-A

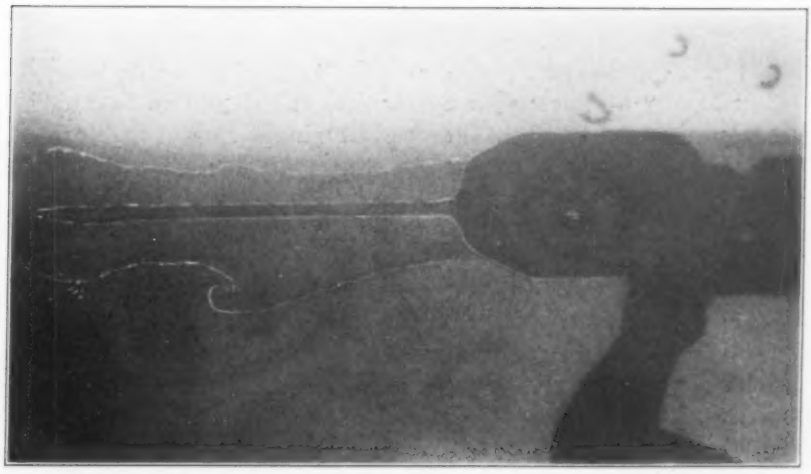

FIG. 5-B

Anteroposterior and lateral views of drill about to penetrate the epiphyseal cartilage.

FIG. 6

The same case as in Figs. 1, 2-A, and 2-B three months after the drilling operation. Note that the head has become firmly fused to the neck.

to,—namely, a slight limitation of internal rotation and of abduction. Limitation of internal rotation is best demonstrated by flexing both hips and internally rotating both thighs at the same time. This prevents any compensatory motion of the pelvis which might confuse the observer. There is rarely any limitation of flexion or extension. The limitation is usually slight and it may disappear if the patient rests in bed for a few days. There is little or no tenderness and no swelling. In other words, the objective symptoms are so slight as to be misleading unless one understands their significance.

The term "preslipping" is a misnomer and should be discarded because from the outset a slight degree of slipping is present and forms the basis for both the characteristic roentgenographic changes and the physical signs.

If the diagnosis is made in the early stage, a number of methods may be employed which, in our experience, have given excellent functional results. The essential principle of all these methods is fusion of the head to the neck by replacement of the cartilaginous epiphyseal plate with bone. In some instances, particularly in older children, simple fixation of the leg in plaster-of-Paris in a position of abduction and external rotation is sufficient for this purpose. This method, however, has its limitations; a long period of time is frequently necessary and L'Episcopo has demonstrated a slipping which occurred in one of his patients while this method was being carried out. (See Figures 3-A and 3-B.) Far more effective are the operative procedures. The head can be fixed to the neck

by means of a Smith-Petersen nail, a bone graft, or wire screws such as are used for the fixation of a femoral-neck fracture. Figure 4 illustrates the solid fusion secured through the use of the tibial bone graft.

Jahss has traumatized the epiphyseal plate by hitting the trochanter a sharp blow with the Cotton mallet. In his series of cases, fusion resulted in all without evidence of arthritic changes in the bone.

The author's own preference has been the drilling method first instituted in this country by Bozsan and Telson. In this technique the leg is first manipulated, so as to secure full range of external rotation and abduction. A three-inch incision, extending from the trochanter downward on the outer side of the femur, is then made. The subtrochanteric region is exposed and a hand drill is inserted in the direction of the femoral neck. Control roentgenograms are taken both in the lateral and anteroposterior views to determine the accuracy of the location of the drill. (See Figures 5-A and 5-B.) When it is certain that the drill is aimed directly at the epiphyseal plate, it is advanced until the plate is perforated. This procedure is repeated at seven or eight different points. The leg is then immobilized in plaster-of-Paris in a position of abduction and external rotation. This spica is left in place for ten weeks. At the expiration of this time, control roentgenograms are taken to determine whether the epiphyseal cartilage has been replaced by bone. If so, the patient is allowed to begin walking; if not, plaster is reapplied and kept in place until fusion is visible roentgenographically. (See Figure 6.) In no case has this required more than four months. The average period has been three months. About twenty cases have been treated by this method; in all of them in which the diagnosis was made early when the slipping was extremely slight, the result has been normal function of the hip and a perfect gait.

SUMMARY

Early diagnosis is the key to successful treatment of slipping of the upper femoral epiphysis. The diagnosis can be made with certainty from the history, the physical signs, and the characteristic roentgenographic picture. Treatment should be instituted at once and should be carried through until bony fusion has occurred between the head and the neck. This can be secured by either a Smith-Petersen nail, or a bone graft, or bone screws, or impaction, or the drilling method.

REFERENCES

Bozsan, E. J.: A New Treatment of Intracapsular Fractures of the Neck of the Femur and Calvé-Legg-Perthes' Disease. J. Bone and Joint Surg., XIV, 884, Oct. 1932.

Jahss, S. A.: Slipping of the Upper Femoral Epiphysis. Treatment in the Pre-Slipping Stage. J. Bone and Joint Surg., XV, 477, Apr. 1933.

Key, J. A.: Epiphyseal Coxa Vara or Displacement of the Capital Epiphysis of the Femur in Adolescence. J. Bone and Joint Surg., VIII, 53, Jan. 1926.

Milch, Henry: Epiphysiolysis or Epiphyseal Coxa Anteverta. J. Bone and Joint Surg., XIX, 97, Jan. 1937.

Pomeranz, M. M., and Sloane, M. F.: Slipping of the Proximal Femoral Epiphysis. Therapeutic Results in One Hundred and One Cases. Arch. Surg., XXX, 607, 1935.

PHYSIOLOGICAL CONSIDERATIONS IN THE TREATMENT OF FOOT DEFORMITIES

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Because of its design, the foot has long been recognized as a specialized organ for man's upright carriage of his body. Its unique morphology means, therefore, that the foot possesses a specific and localized range of function which qualifies it as a distinct physiological unit in the general phenomenon of locomotion.

If only a single block of bone were positioned beneath each leg to serve as a foot, locomotion would be very much of a peg-legged performance, and little opportunity would be given for local physiological study except for such facts as pertain to the normal interactions and relationship between that single bone and the leg. But nature has fashioned a far more efficient structure for a foot, and in its complexity of design and parts has implanted a specific sphere of physiological activity. Like the eye, the foot is an end-organ, both being terminal structures of their respective visual and locomotor systems. In one case, the eye with its lens is designed to transmit light rays from outside onto the retina, so that clearly defined image-impulses are relayed to the brain by the intervening nerve channels. Similarly, the foot with its supporting framework is designed to divide and to transmit body weight received upon the talus from the leg bones to various points of ground contact in accordance with a definite ratio of distribution. Thus, just as refraction of light rays within the eyeball is a distinct and localized entity in the complete phenomenon of sight, so the ordered division and transmission of stresses between the ankle and the ground characterizes the specialized function of the foot.

The *distribution*, *course*, and *intensity* of those stresses, as influenced by gravity and propulsive effort, comprise the intimate sphere of foot "physiology". It must be distinguished from the correlationship between foot and leg,—the adjacent phase of locomotion which is centered upon the ankle. Both are so closely associated, however, that disturbance in one is immediately reflected upon the other. As a result, the more visible signs of disordered relationship at the ankle have caused this phase to receive attention so predominantly that the importance of what takes place *inside* the foot has largely been left in obscurity. Actually, recognition of an internal physiology of the foot leads to clearer identification and localization of causative factors in foot disorders, and offers most promising opportunities for their study and treatment along physiological lines which so far have not been developed.

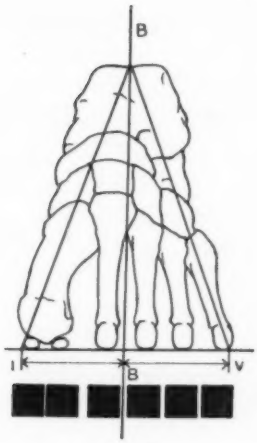

FIG. 1

Normal foot posture and weight distribution in stance. The ratio of 2, 1, 1, 1, 1 is represented in the equal-sized black squares.

BB: Vertical plane of balance.

IB and *BV:* Medial and lateral margins of structural stability.

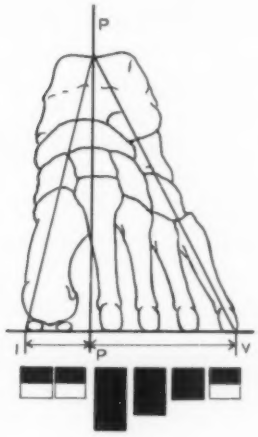

FIG. 2

Mild pronation. Note concentration of weight on the second metatarsal.

PP: Vertical plane projected from centers of ankle and heel contact.

IP: Reduced medial margin of stability.

PV: Lateral margin.

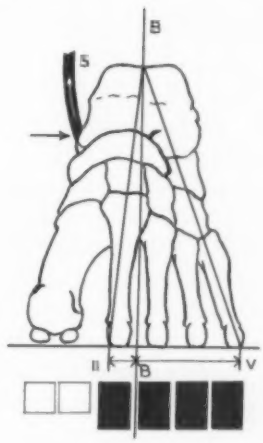

FIG. 3

Pronation corrected by supinator action. (Compare with Fig. 1.) Note non-contact of the first metatarsal and difference in weight distribution; also the reduced medial margin (*II-B*) of structural stability.

S: Supinator muscles exerting lateral pressure against foot to sustain corrected posture.

Staticometric tests described in full elsewhere[2], have shown that in stance the ratio of weight distribution to the heel posteriorly, and to the five metatarsals anteriorly, conforms closely with the formula 6: 2, 1, 1, 1, 1. The metatarsal portion (2, 1, 1, 1, 1) of the formula is of special importance, because the ratio prevailing in stance predetermines the comparative load on each metatarsal bone when all the stresses are projected upon the forepart of the foot in locomotion. Also, for its significance in clinical disorders, the following statement should be added: With any existing variation in that ratio, the differences are multiplied in locomotion according to the strength of the propulsive effort.

One of the most common sources of pronation deformity is found in the laxity of the ligaments of the first metatarsal segment. This laxity deprives that member of its normal supporting contact, so that the foot rolls inwardly until ground contact is gained by this bone. If the defect is of moderate degree, the ratio may be altered from 2, 1, 1, 1, 1 to 1, 2, 1.5, 1, 0.5 (Figs. 1 and 2). Weight is concentrated on the second metatarsal, because it must serve as the pivot for pronation until the first metatarsal comes in contact with the ground.

If a patient with such feet is told to elevate the inner borders by voluntary muscular effort, the faulty posture can be overcome easily. This gives the feet a normal appearance morphologically, but physiologically the conditions are by no means corrected (Fig. 3). The first

metatarsal has been lifted from supporting contact with the ground and its share of body weight has been transferred upon the four lateral metatarsals; also the medial stability of the foot—now supplied by supinator effort—will be continued only so long as the muscles can sustain their voluntary contraction. In this condition, the cause is primarily *intrinsic*, being located within the foot structure; the postural effect upon the ankle is secondary.

In contrast, a paralytic weakness of the supinators in a hitherto normally balanced foot gives a different disturbance in ratio. As pronation develops through loss of muscle balance, body weight is concentrated directly on the first metatarsal until the intensified stresses and their distorted movement break down the inner border of the foot. Here the primary cause is *extrinsic* as the affected muscles lie above the ankle, and the foot's mechanism is affected secondarily. Short calf muscles are another extrinsic factor, which also concentrate weight stresses directly upon the inner border of the foot and the first metatarsal, in producing pronation deformity.

These examples indicate very simply how physiological considerations in weight distribution are applicable to clinical studies. In severe deformities their application is more complicated, but correspondingly more valuable, because extensive remodeling of the framework of the entire foot may be required. Consequently, familiarity with the functional value of each structural unit will be useful in devising with precision the most effective plan of treatment.

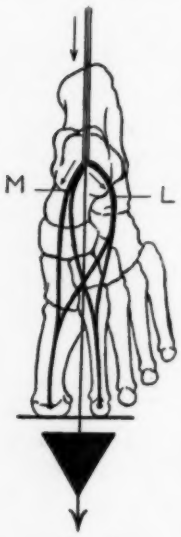

FIG. 4

Divergence of the medial (*M*) and lateral (*L*) movements of stress for counterbalance on the leverage axis (long arrow) of the foot.

In an extreme case of congenital talipes equinovarus, weight stresses are directed entirely upon the fifth metatarsal bone whose lateral side alone gives the foot its single point of contact with the ground. Graphically, it presents the very unbalanced ratio of 0, 0, 0, 0, 6.

There is one structural feature in the foot whereby weight stresses are initially separated into two anterior channels (Fig. 4) in order to create normal balance; it consists of a mild downward and inward slant of the sustentaculum tali. The degree of slant determines the proportion of stresses which

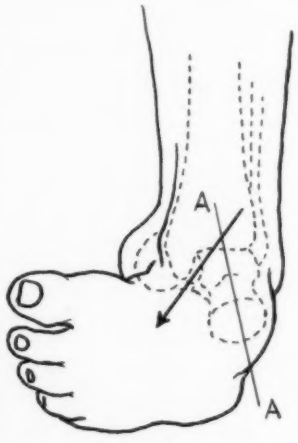

FIG. 5

Congenital talipes equinovarus, showing supination with its inversion of the calcaneum. The axis of the talus (*AA*) should normally be in line with the arrow to ensure proper weight distribution through the forepart of the foot.

are directed toward the medial side of the foot, and concurrently it controls the angle of deviation which the axis of the talus bears to the axis of the foot. In fact, this shelf-like process of the calcaneum may logically be viewed as the center of the foot's balancing mechanism. When its downward slant is increased beyond normal (as in pronation, flat-foot) body weight is more heavily thrown upon the inner border of the foot, and the medial deviation of the talus is widened (inward rotation).

In club-foot the opposite condition prevails. The supination element of deformity, emphasized so strongly by Kite, holds the calcaneum so inverted that the sustentaculum tali slants *upward*. As a result, all weight stresses are deflected toward the lateral border of the foot and, helped by the varus deformity, the talus is obstructed and held in a position where its axis deviates *laterally* to the foot's axis. Thus, physiological analysis reveals the vital importance of overcoming completely the inversion deformity of the heel in order to obtain normal balance for the foot, and designates the position of the talus as a valuable index to the necessary degree of correction. Elimination of varus and subsequently of the equinus deformity are also important steps in treatment, but these elements are so apparent morphologically that their correction has more generally conformed with physiological requirements.

Limited space prevents more extensive discussion of the application of these physiological principles. Their value can be more fully appreciated and developed only by use. In representing conditions of normal foot function, the formula 6: 2, 1, 1, 1, 1 supplies a fixed criterion toward which all corrective measures may advantageously be aimed. Although the formula submitted was obtained by means of specially designed apparatus, there are physical signs revealed in posture, in thickening of the skin under the metatarsal heads, and in roentgenograms, which identify quite effectively departures from normal weight distribution, as follows:

1. *Posture.* In the normally balanced foot, a vertical plane passes through the centers of the heel and ankle and is projected forward between the second and third metatarsals, thus dividing the entire load into equal longitudinal halves (2, 1) (1, 1, 1). (See Figure 1.) Any change from normal posture causes an inevitable distortion in the metatarsal ratio.

2. *Callus Formation.* In adults, examination of the texture of the skin across the metatarsal region of the sole is a very reliable test. Any uneven distribution of a heavier texture, ranging from a mild thickening to a marked callosity, is direct evidence of an overload on the corresponding metatarsal bone or bones.

3. *Roentgenograms.* In the dorsoplantar view of a foot with ideal design, the four lateral metatarsals have the same diameter of shafts and cortical thickness. Widening of the shaft and thickening of the cortex (most frequently affecting the second metatarsal) are positive signs of abnormally increased burden and strain. Lessened develop-

ment may be observed in the other metatarsals whose burden has been correspondingly reduced.

Modern strides in all fields of medicine have been based upon advances in physiology rather than in morphological knowledge. Moreover, just as the great majority of visual disturbances are due to disorder or defects in the eye as the peripheral organ, so the most common site of disorder in the locomotor system is its terminal structures—the feet. It would seem, therefore, that inestimable benefits might attend full recognition of the *internal physiology of the foot* and its inevitable relation to those disorders and their treatment.

REFERENCES

1. KITE, J. H.: The Treatment of Congenital Club-Feet. Surg. Gynec. Obstet., LXI, 190, 1935.
2. MORTON, D. J.: The Human Foot. New York, Columbia University Press, 1935.

CHIP GRAFTS IN ORTHOPAEDIC SURGERY

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Without entering into any discussion of the merits of the various operative procedures employed by others for bone fusion, the author wishes to call attention to the wide range of usefulness of chip grafts. The cases presented herewith have been followed long enough to demonstrate the certainty of fusion by the author's methods. They illustrate the ease with which fusion may be obtained by chip grafts whenever strength of graft is not needed for fixation.

For the past eleven years the author has employed the multiple chip-graft method of spinal fusion as reported in 1932, and the results have been uniformly satisfactory. The detailed operative technique was presented in 1933 after having been successfully employed in over seventy-five cases. Liebolt's recent review of mortality statistics in orthopaedic surgery indicates that surgical shock is still a frequent cause of death, and that it is most common in extensive spinal fusions. There has been no death from surgical shock in spinal fusions by the chip-graft method in any of our cases. Six to eight vertebrae can be fused together easily and safely in an

FIG. 1

Healed tuberculous spine, eighteen months after operation.

FIG. 2

Recurrent back strain, three months after operation.

FIG. 3

Structural scoliosis, ten months after operation.

FIG. 4

Spondylolisthesis, two years after operation.

FIG. 5

Eight weeks after Dickson roofing operation for old congenital dislocation of the hip.

hour or less by using a second operating team to remove the chips from the tibia. The laminae are prepared first by scraping with a blunt osteotome, and then by raising thin cortical shavings from them with a hand chisel, which eliminates the shock of hammering upon the spine. The risk of fat embolism is considerably reduced by removing only osteoperiosteal and cortical chips from the tibia without opening the medullary cavity. "Bone marrow is the common source of the fat which gives rise to fat embolism" as Harris has shown, and the use of spongy bone with this additional risk is unnecessary. (See Figure 1.)

The great advantages of chip grafts are that they are always handy, that almost any quantity is available,

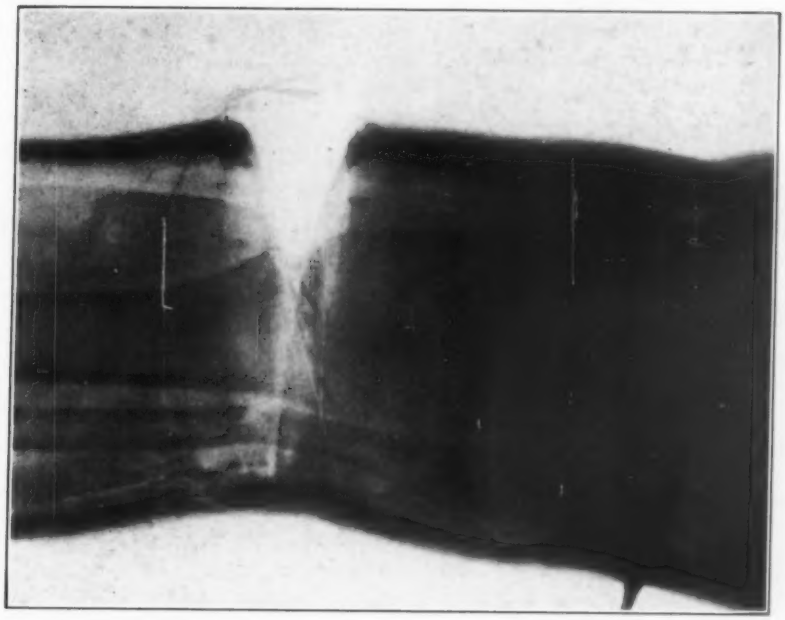

FIG. 6-B
Opening osteotomy of the tibia.

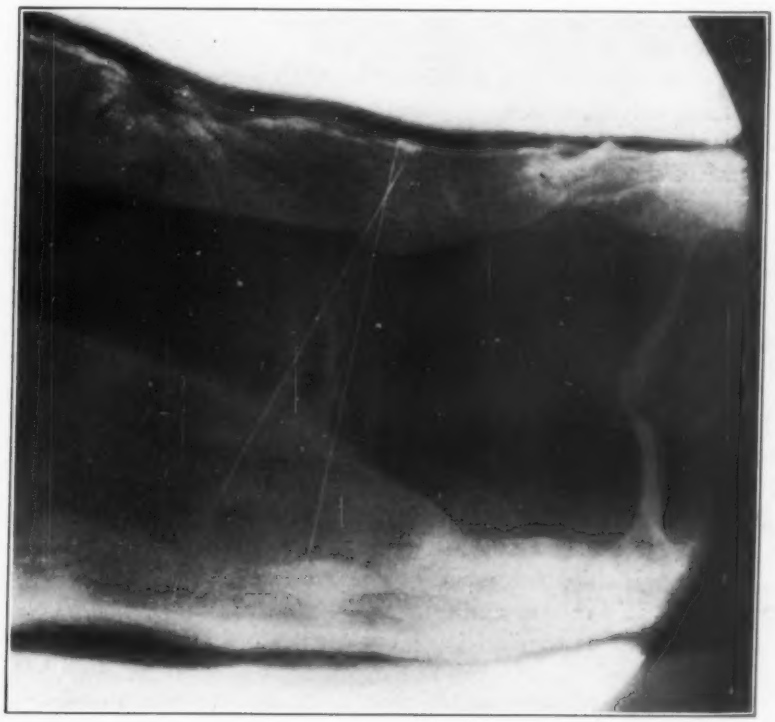

FIG. 6-A
Opening osteotomy of the femur.

FIG. 7-A FIG. 7-B

Giant-cell tumor of the tibia, three months after operation.

and that no special apparatus is needed for their removal. Grafts larger than the fingernail are unnecessary and interfere with the close coaptation between grafts which is needed for good fusion. Chip grafts are probably revascularized more easily than large grafts, and they may be absorbed if not in close contact with the host and with each other. In the presence of complicating sepsis, of course, they die and are extruded. In none of the author's cases has a graft necrosed or sequestrated, unless sepsis intervened.

The amount of new bone formation is important in old compression fractures, in spinal tuberculosis, in lumbosacral fusions (Fig. 2), in scoliosis (Fig. 3), and in spondylolisthesis (Fig. 4) where the fused area will ultimately be subjected to considerable strain. If necessary, both tibiae can be used and massive fusions produced which eliminate the danger of "fracturing the graft".

In the arthrodesis of large joints, bone fusion is augmented and hastened by the use of chip grafts. In fusing the hip, knee, ankle, or shoulder, enough chips can usually be borrowed from adjacent exposed bones to fill tightly the remaining cavities. The Campbell operation for arthrodesis of the sacro-iliac joint can be strengthened by additional tibial chip grafts. The Dickson roofing operation for congenital dislocation of the hip may be simplified by turning down flaps from the ilium, reflecting the entire acetabular roof downward, and then packing additional

tibial chips in tightly behind the flaps to hold them in position anteriorly and posteriorly, as well as superiorly.

In corrective osteotomies of the lower extremities, union is hastened and length is gained by opening the transverse osteotomy and filling the gap with chips. (See Figures 6-A and 6-B.) The use of bone chips and osteoperiosteal grafts to augment inlay grafts in osteosynthesis of the long bones is well known; they furnish osteogenic material for earlier union while the massive graft furnishes fixation.

In the surgical treatment of certain bone tumors, such as cysts, giant-cell tumors, osteitis fibrosa, and benign types of chondrosarcoma, bone chips are increasing in popularity. (See

FIG. 8

Osteitis fibrosa of the femur, seven weeks after operation.

FIG. 9-A

FIG. 9-B

Chondrosarcoma of the sternum before operation and two years after operation.

FIG. 10-B
Bone cyst of the humerus two years after operation.

FIG. 10-A
Bone cyst of the humerus before operation.

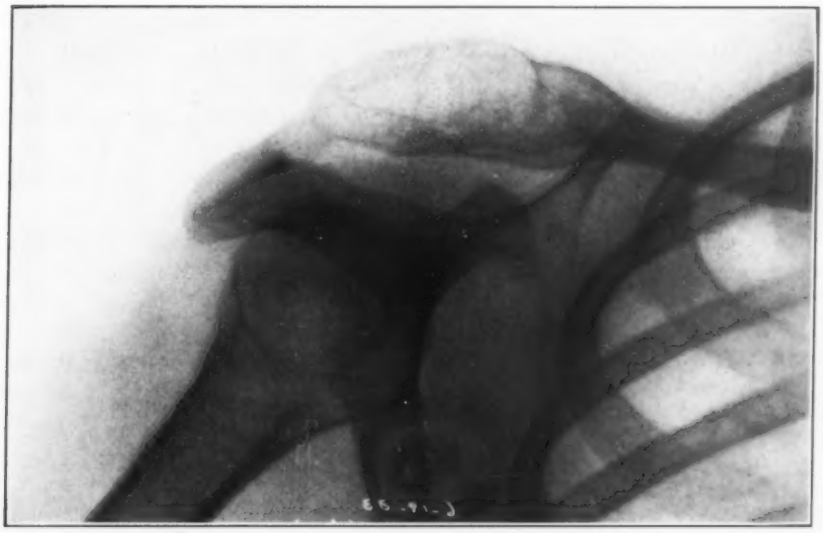

FIG. 11-A
Osteitis fibrosa of the clavicle.

FIG. 11-B
Osteitis fibrosa of the clavicle six months after operation.

Figures 7-A, 7-B, 8, 9-A, 9-B, 10-A, 10-B, 11-A, and 11-B.) After the tumor cavity has been thoroughly cleaned out and cauterized, bone chips removed by the second operator are packed tightly into the cavity to fill it completely. This method, as Meyerding also found, "aids in filling the defect and stimulates the formation of bone". It can be carried out quickly and easily with little surgical trauma to the leg furnishing the grafts.

SUMMARY

1. Chip grafts have a wide range of usefulness in orthopaedic surgery.

2. The dangers of surgical shock and fat embolism in spinal fusions are diminished by the chip-graft method.

3. Handy chip grafts are easily obtained in large quantities without special instruments.

4. Chip grafts hasten and ensure bony union in many orthopaedic operations.

REFERENCES

Dickson, F. D.: The Operative Treatment of Old Congenital Dislocation of the Hip. J. Bone and Joint Surg., VI, 262, Apr. 1924.

Harris, R. I.: Fat Embolism. Canadian Med. Assn. J., XXXIV, 166, 1936.

Henry, M. O.: Tuberculosis of the Fifth Lumbar Vertebra with Spina Bifida Occulta. Spinal Fusion and Cure. Case Report. J. Bone and Joint Surg., XIV, 690, July 1932.

Henry, M. O., and Geist, E. S.: Spinal Fusion by Simplified Technique. J. Bone and Joint Surg., XV, 622, July 1933.

Liebolt, F. L.: Mortality in Orthopaedic Surgery. Twenty-Three-Year Report of the New York Orthopaedic Dispensary and Hospital. J. Bone and Joint Surg., XIX, 163, Jan. 1937.

Meyerding, H. W.: Treatment of Benign Giant-Cell Tumors. J. Bone and Joint Surg., XVIII, 823, Oct. 1936.

STUDIES IN BONE FORMATION: THE EFFECT OF THE LOCAL PRESENCE OF CALCIUM SALTS ON OSTEOGENESIS

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One of the unsolved problems of ossification is the origin of the calcium which is deposited in organic bone matrix to form bone. Numerous investigators of the biochemical aspects of bone formation have failed to agree on the source of this calcium. The object of this paper is to report the results of efforts to investigate bone formation in the presence of various calcium salts.

INTRODUCTION

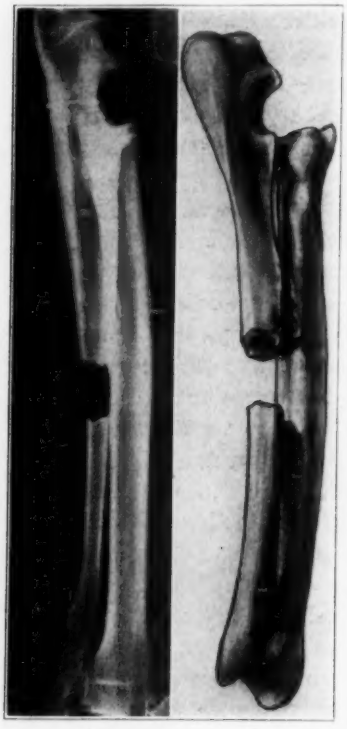
One of the first investigations of the nature of bone was made by Clopton Havers, of London, in 1691. This contribution immortalized his name and in it he first described the small canals, now spoken of as haversian canals. He did not accept the work of Harvey on the circulation of the blood, however, and failed to recognize that small blood vessels traverse these passages. In the eighteenth century John Hunter showed that bone substance is not the static resistant structure it appears to be, but that it exists in a state of constant deposition and resorption and that this activity is the important element in bone repair. This work was confirmed in 1847 by Flourens of France. Later in the nineteenth century biochemists proved by chemical experimentation that the two processes of calcium resorption and deposition are coexistent as the two elements of a reversible equation in which the inorganic calcium carbonates and phosphates represent one variable and the complicated organic salts the other. H. G. Wells, in 1911, wrote that the calcium salts exert a specific influence on the connective-tissue cells which cause them to assume active growth and to undergo a metaplasia not only into osteoblasts and bone corpuscles but apparently even into marrow cells with hematogenic function. Wells states: "In the blood we have present the anomalous condition of calcium in solution in a fluid containing carbonates, phosphates and sulphates, any one of which would throw it down in the test-tube. . . . Yet in the blood stream calcium remains in a soluble form. . . . Therefore, finding no clue [to account for the calcium deposition] on the chemical side, we naturally turn to the physical aspects." He further states that taking all the evidence as it stands we find ourselves best satisfied with that which indicates that calcification begins as a simple physical adsorption by hyaline substances which have a more or less specific adsorption affinity for calcium.

The validity of Wells's original hypothesis has been proved by Leriche and others. This hypothesis holds that whatever the chemical nature

of the reaction, given a proper physical environment within the organism such as an area of tissue necrosis or localized formation of hyaline substance, calcification is likely to occur, and, following calcification under such circumstances, ossific metaplasia may be expected. This is true of the normal as well as of the pathological development of bone.

Robison, working in England in 1923, succeeded in isolating an enzyme which by hydrolysis causes the deposition of calcium from organic salts such as the calcium phosphoric esters of hexose which are present in the blood stream. He believed that this enzyme is secreted in the region of the osteoblasts and the hypertrophic cartilage cells. The enzyme was called "phosphatase" because it has become recognized that in the process of calcification the phosphorus radicals are the hydrolyzable elements.

Another school of thought in bone investigation, opposed to the humoral or chemical hypothesis, was composed of a group of men who believed that bone is formed by the direct action of specific cells according to a cellular or vital action. John Goodsir, Professor of Surgery at the University of Edinburgh at the beginning of the nineteenth century, believed that a specific cell, such as the osteoblast, is an actual builder of bone and utilizes the material of its environment in the building process. William MacEwen later in the nineteenth century experimented along these lines and in 1912 published a classical monograph on bone formation. Like Goodsir, MacEwen was an advocate of the cellular theory, believing that osteogenesis is the function of osteoblasts alone and that resorption is effected by another group of tissue cells, the osteoclasts.



A B

FIG. 1

Typical defect in ulna. (This dog died one day after operation.)
A: Roentgenogram.
B: Drawing of specimen.

During this same period, Ollier in France carried on a rather extensive series of experiments in bone formation. He believed that the periosteum is the mother tissue of bone and that the cambium layer of this membrane is by far the most important factor in the production of bone cells. He also believed that the bone marrow possesses an osteogenic power and that cortical bone itself is the least important factor in bone growth. MacEwen, after extended experimentation, was apparently of the same opinion.

The work of Leriche and Policard on the physiology of bone, published in recent

years, has already become a classic. These authors are champions of the humoral or chemical theory and postulate "a local calcific surcharge as the determinant of osteogenesis in a suitable fibrous medium". They believe that with the rarefaction of fracture fragments calcium salts are liberated in the vicinity, leading to a local excess of calcium, and that this calcium is an important factor in the union of fractures. Murray, after exhaustive experimentation, believes that calcium phosphate and carbonate in the proportion in which they occur in the bone can be used as a local calcium depot in the process of bone formation and that they form a stimulant to osteogenesis. Key has been unable to confirm the work of Murray. From his experiments upon dogs he concludes:

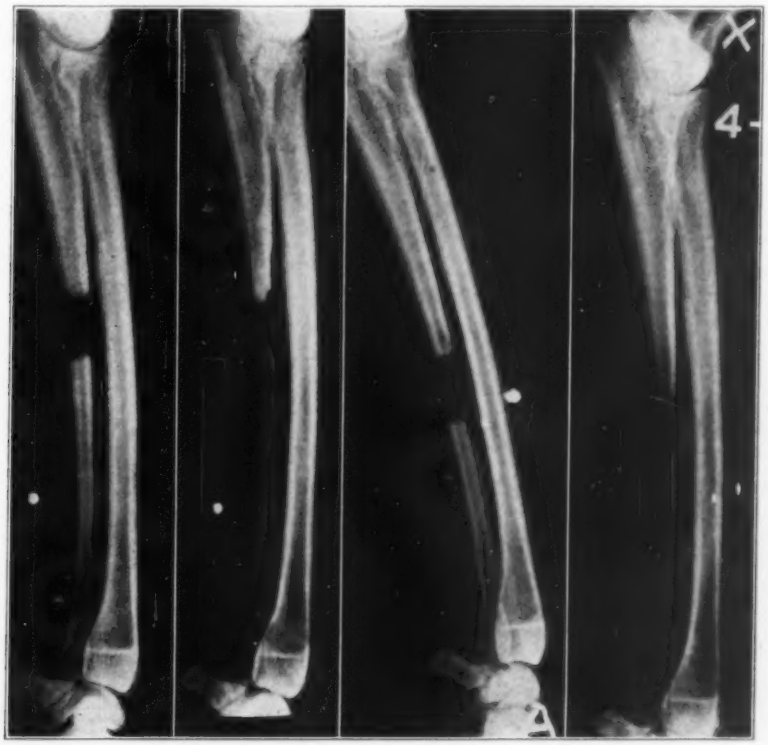


FIG. 2

Experimental (*A* and *B*) and control (*C* and *D*) defects in same dog.
A: One day after operation. Defect filled with calcium glycerophosphate.
B: Twelve weeks later. There is slight proliferation of bone with decrease in the width of the defect.
C: One day after operation. Defect not filled with calcium glycerophosphate.
D: Twelve weeks later. There is absorption and atrophy of bone ends with increase in the length of the defect.

"Neither calcium phosphate and carbonate in the proportion in which they occur in bone, nor bone powder, made by removing the organic matter from bone, appear to stimulate osteogenesis of bone when im-

planted in a bone defect." This same opinion is held by Phemister. In the presence of these differences of opinion the problem is distinctly unsolved. The author's personal interest in this investigation has been stimulated by contact with Murray. The present investigations were carried out from 1931 to 1933 and constitute an attempt to prove or to disprove that calcium salts at the site of new bone formation stimulate osteogenesis.

EXPERIMENTS

A preliminary group of experiments on seventeen dogs were performed in an attempt to determine which salts of calcium are associated with the most rapid bone formation. With a burr, one centimeter in diameter, a hole was bored from the flat outer surface of the upper portion of the tibia into its medullary cavity. The hole was then filled with calcium salts. The controls were of two kinds: (1) the holes were filled with bone chips, and (2) the holes were left empty. Three types or combinations of calcium salts were used:

1. Calcium triple phosphate, three parts; calcium carbonate, one part,—the same proportion as found in the blood.
2. Calcium glycerophosphate, which has been shown to be the calcium salt upon which the enzyme phosphatase has the most specific action in bone formation.
3. Bone ash, which contains, in addition to calcium phosphate salts, magnesium and iron as chlorides and sulphates whose influence on bone formation is unknown.

Of the seventeen dogs, twelve were suitable for providing reliable data. The defects were examined in from three to eleven weeks after operation; all of them contained solid bone. More bone was found in the control defects than in those filled with calcium salts. Defects containing calcium glycerophosphate showed a larger amount of bone formation than those in which the other salts of calcium had been used.

TABLE I

CALCIUM SALTS EXPERIMENTS—FIRST SERIES: THE ULNA

Type	No. of Experiments	Average Volume of Bone Formation (*Per Cent.*)	Group Average (*Per Cent.*)
Calcium glycerophosphate	12	43.3	43.2
Calcium triple phosphate (3 parts) Calcium carbonate (1 part)	6	36.6	
Bone ash	4	40.0	
Calcium gluconate	3	60.0	
Control	6	20.0	20.0
Total	31		

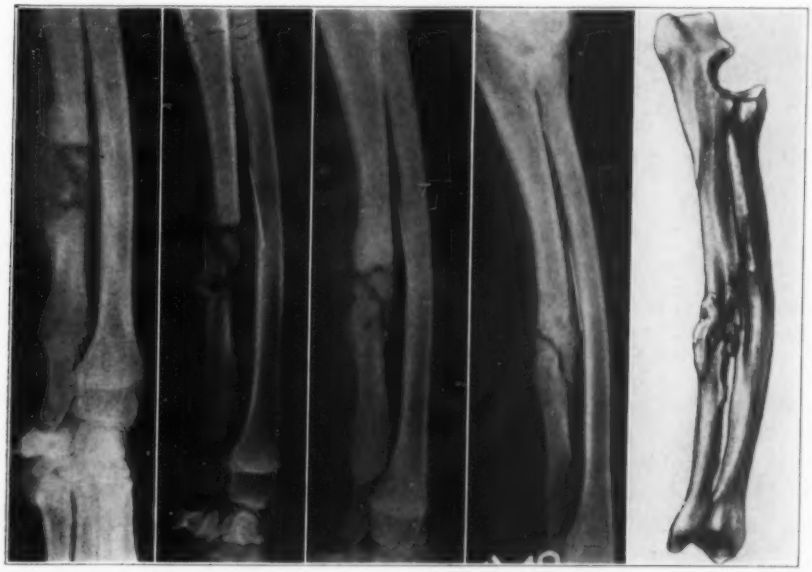
TABLE II

CALCIUM SALTS EXPERIMENTS—SECOND SERIES: THE ULNA

Type	No. of Experiments *	Average Volume of Bone Formation (*Per Cent.*)	Average Percentage of Defect Containing New Bone Formation
Calcium glycerophosphate	7	40.0	49.1
Control	7	20.0	40.7
Total	14		

* The same animals (7) were used for both experimental and control operations.

Following these preliminary experiments, a series of experiments on thirty-nine dogs were started. Thirty-one of these animals proved satisfactory for furnishing experimental data. A defect about one and five-tenths centimeters in length was created in the middle third of the ulna and filled with the calcium salts. The periosteum was removed as carefully and as completely as possible. The bone was taken out by the use of Gigli saws and bone cutters. Great care was used not to injure the adjacent portion of the radius. This procedure was carried out in twenty-five dogs, while in a control group of six animals the same technique was



A B C D E

FIG. 3

Roentgenograms and specimen after calcium glycerophosphate had been placed in the defect in the ulna. Roentgenograms (*A*) three weeks, (*B*) seven weeks, (*C*) eleven weeks, and (*D*) six months after operation. Specimen (*E*) six months after operation. Note the progressive increase in the amount of bone formation in the defect. The specimen appears to show solid union, but the last roentgenogram shows that the union is still incomplete.

used without the addition of the calcium salts. None of the control operations were performed in the same animal as the experimental operations. The dogs were all adult animals but varied from distinctly small to large size. After the first one or two experiments no attempt was made to immobilize the leg in plaster. Calcium gluconate, which is so often employed clinically as a source of calcium, was used in addition to the calcium salts previously mentioned. The experiments were allowed to run for from three weeks to ten months. Roentgenograms were taken at different intervals, but unfortunately not at the same time interval in each case. The amount of bone formation has been estimated at the time of the last roentgenogram as well as at the time of the postmortem examination. This has been expressed in terms of the estimated percentage as follows: A slight amount of bone formation has been rated 20 per cent.; a small amount, 40 per cent.; a moderate amount, 60 per cent.; a large amount, 80 per cent.; and solid union across the gap, 100 per cent. It is realized that this is entirely a personal estimate and that it is not exact. Table I shows the averages of the total number of experiments with each calcium salt and the controls.

FIG. 4

Roentgenograms and specimen after calcium glycerophosphate had been placed in the defect in the ulna. Roentgenograms (*A*) six weeks, and (*B*) one year after operation. Specimen (*C*) one year after operation. The defect has been completely filled with new bone.

The largest group of experiments were done with calcium glycerophosphate, because of its being most subject to the specific action of phosphatase and because from the preliminary work it was found that bone formation was most abundant with this salt. In this series there is no greater bone formation with calcium glycerophosphate, however, than with the other salts, but the number of experiments with the other salts is small. The average volume of bone formation when calcium salts

are present is 43.2 per cent., as compared with 20 per cent. for the controls; this represents a ratio greater than 2 to 1.

From the experience gained with the first series, it was believed that there were a great many sources of error which might influence the results. The following points were taken into consideration in a second series: The dogs were more nearly the same size; the location of the ulnar defect was more uniform; and exactly the same length of bone was removed from each animal (this was done by using a double motor saw with the blades set apart at a distance of one and five-tenths centimeters). Great care was taken not to cause excessive bleeding. The operative field was thoroughly washed out with saline solution after the removal of the bone segment and its periosteum. All roentgenograms were taken at exactly the same distance with the same exposure, in order to secure comparable records of bone density. Experimental and control operations were done upon the same animal, the right leg being used for the control and the left leg for the experiment. Roentgenograms were made at intervals of approximately one day, one week, two weeks, four weeks, eight weeks, and twelve weeks. In each case the last roentgenogram was made twelve weeks after operation. Calcium glycerophosphate alone was employed in this series. Thirteen animals were used. Six of these either became infected or died, seven satisfactory experimental animals remaining. The aver-

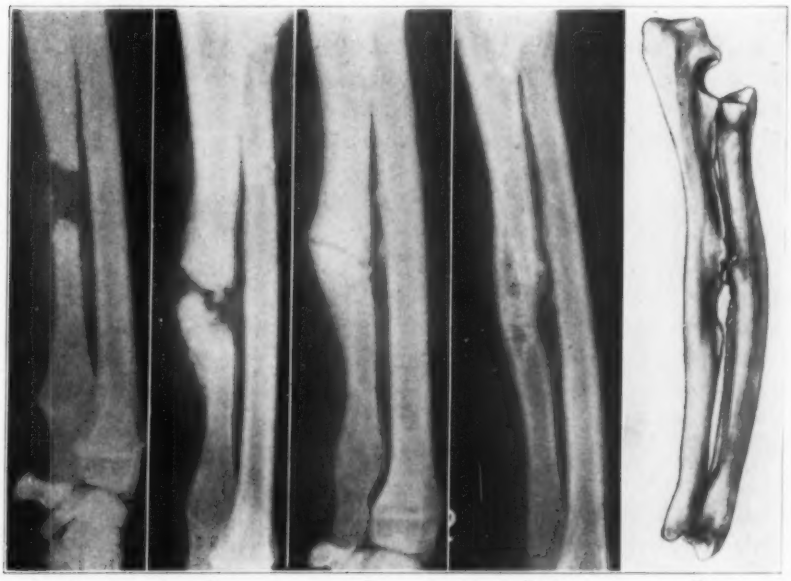


FIG. 5

Roentgenograms and specimen after calcium triple phosphate (3 parts) and calcium carbonate (1 part) had been placed in the defect in the ulna. Roentgenograms (*A*) one week, (*B*) five weeks, (*C*) ten weeks, and (*D*) six months after operation. Specimen (*E*) eight months after operation. Note that the gradual increase of new bone fills the defect completely in six months.

TABLE III

CALCIUM SALTS EXPERIMENTS—COMBINED FIRST AND SECOND SERIES: THE ULNA

Type	No. of Experiments	Average Volume of Bone Formation (*Per Cent.*)
Calcium salts	32	42.5
Control	13	20.0
Total	45	

age volume of bone formation was 40 per cent. for the experimental bones and 20 per cent. for the controls. (See Table II.) The roentgenograms were also studied to determine the percentage of the defect which contained new bone formation regardless of the bone volume. It was found that in the experimental bones 49.1 per cent. of the length of the defect contained new bone, while in the controls 40.7 per cent. of the length showed new bone formation.

Table III shows the combined first and second series. There were thirty-two experimental and thirteen control operations, or a total of forty-five experiments. The average volume of bone formation was 42.5 per cent. for the experimental and 20 per cent. for the control operations, a ratio of 2.1 to 1. The results of these experiments certainly suggest that in bone formation in the ulna the local presence of calcium salts stimulates the process. This does not prove, however, that they supply the calcium actually used in the calcification of the organic bone matrix.

A third series of experiments were performed in an attempt to determine whether the local use of calcium glycerophosphate in spine-fusion operations is of value. The surgical procedure which was used in all of the experimental operations on the spine was a modification of the Hibbs fusion technique. It consisted of removing the spinous processes, chipping up the posterior surface of the laminal arches and the articular facets, and replacing the chips along the raw, bleeding surface of the bones. In all of these experiments from three to four vertebrae were operated upon. Twenty-five dogs were used in this series, seventeen of which were satisfactory for furnishing data. All dogs were sacrificed after twelve weeks. The eight unsatisfactory animals either became infected or died too early to be of value. In seven dogs calcium glycerophosphate was poured into the wound or mixed with the chips. Five dogs were used as controls; in these the chips were employed without the addition of calcium glycerophosphate. In two dogs all of the chips, including the spinous processes, were removed and not replaced; this raw bony surface was then covered with calcium glycerophosphate. In three dogs the same procedure was carried out without the addition of calcium glycerophosphate. Adequate tabulation of the results is difficult. The greatest amount of bone formation and the strongest fusion occurred in the control

A B

FIG. 6

Roentgenogram (*A*) and specimen (*B*) nine and one-half months after the defect in the ulna had been filled with calcium gluconate. Note that approximately three-fourths of the defect is filled with new bone.

A B

FIG. 7

Roentgenogram (*A*) and specimen (*B*) thirteen and one-half months after the defect in the ulna had been filled with bone ash. Note that the ends of the fragments are pointed and that the defect is only slightly shortened by new bone.

A B C

FIG. 8

Roentgenograms (*A* and *B*) and specimen (*C*) of control experiment. No bone salts were placed in the defect in the ulna.

A: One day after operation.

B and *C:* Sixteen months after operation.

Note the absorption and pointing of the ends of the fragments and the very slight shortening of the defect.

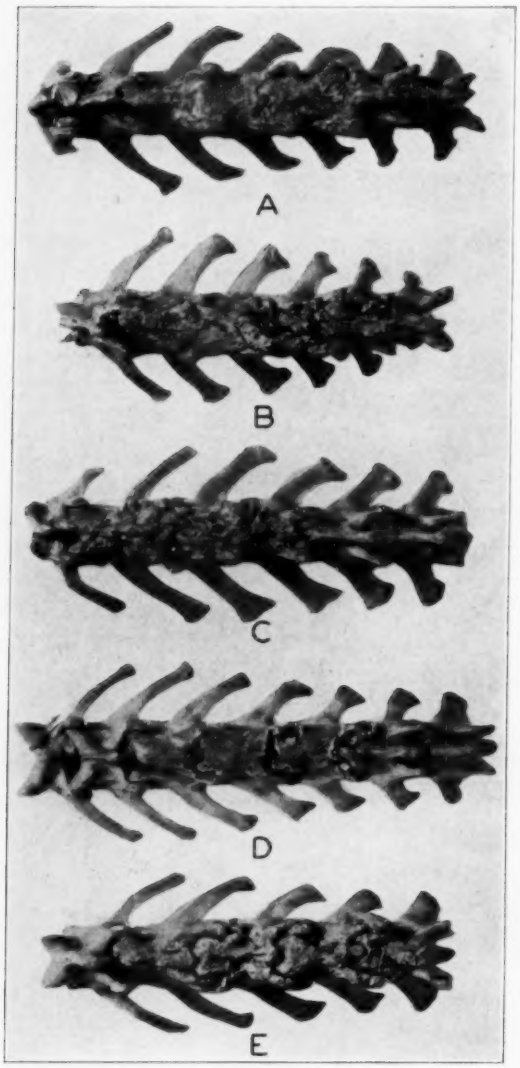


FIG. 9

FIG. 9

Photographs of specimens from spine experiments in osteogenesis. The dogs were sacrificed after twelve weeks.

A: Hibbs fusion—chips not removed, but covered with calcium glycerophosphate. Note the smooth new bone formation; however, there are two places in which the bridging of bone is not complete.

B: Hibbs fusion—control experiment, chips not removed. The amount of new bone formation is greater and the bony union is more solid than in *A*.

C: Hibbs fusion—control experiment, chips removed and replaced. The bony union is firmer than in *A* or *B*.

D: Removal of spinous processes and laminal surfaces; bleeding bone covered with calcium glycerophosphate. Note the almost complete absence of new bone formation.

E: Removal of spinous processes and laminal surfaces. Control experiment. Note the large amount of new bone formation about the articular margins as contrasted with the lack of new bone in *D*.

group of spines fused according to the usual Hibbs technique. (See Table IV.) In three of these five animals the chips were taken out and then replaced along the bleeding surface in regular order; this group showed more bone formation than those in which some of the chips were left partially attached. There was a moderate amount of bone formation in those animals in which the Hibbs fusion had been done with the addition of calcium glycerophosphate, but the spines were not so solidly fused as those in the control animals. In the second group, the most surprising finding was the amount of new bone formed in the spines of control animals from which all of the chips had been removed and to which no calcium salts had been added. There was actually piling up of bone about and around the articular facets and the adjacent laminal arches. There was little bone formation in cases in which calcium glycerophosphate was added after all of the chips had been removed. The five cases

TABLE IV

CALCIUM SALTS EXPERIMENTS—THIRD SERIES: THE SPINE

Type	No. of Experiments	Amount of Bone Formation
1. Hibbs fusion with calcium glycerophosphate	7	Moderate
2. Control—same as No. 1 but without calcium glycerophosphate	5	Large
3. Hibbs fusion without replacement of bone chips and with addition of calcium glycerophosphate	2	Slight
4. Control—same as No. 3 but without addition of calcium glycerophosphate	3	Moderate
Total	17	

in this second series of spines are too few, however, to allow definite conclusions to be formulated. From operating upon these spines and examining the specimens, one gains the impression that calcium salts do not here stimulate osteogenesis as they apparently did in the case of the ulna. The discrepancy is perhaps best explained upon a circulatory basis. The local circulation about the spine is always more abundant than that in the foreleg. It seems likely that in the case of the spine the calcium salts are rapidly absorbed and taken away from the site of bone formation and that this does not occur in the foreleg where the circulation is less plentiful.

CONCLUSIONS

1. In defects in the ulna of the dog, calcium salts appear to stimulate bone formation.

2. In operations upon the spine, calcium salts in the form of calcium glycerophosphate do not stimulate bone formation and appear rather to exert an inhibiting influence.

REFERENCES

ALBEE, F. H., AND MORRISON, H. F.: Studies in Bone Growth; Triple Calcium Phosphate as a Stimulus to Osteogenesis. Ann. Surg., LXXI, 32, 1920.

FLOURENS, J.-P.-M.: Théorie expérimentale de la formation des os. Paris, J.-B. Baillière, 1847.

GOODSIR, JOHN, AND GOODSIR, H. D. S.: Anatomical and Pathological Observations. Edinburgh, M. Macphail, 1845.

HAVERS, CLOPTON: Osteologia Nova or Some New Observations on the Bones and the Parts Belonging to Them, with the Manner of Their Accretion and Nutrition. London, S. Smith, 1691.

HUNTER, JOHN: The Works of John Hunter, With Notes. Edited by James F. Palmer. London, 1837.

KAY, H. D.: Phosphatase in Growth and Disease of Bone. Physiol. Rev., XII, 384, 1932.

KEY, J. A.: The Effect of a Local Calcium Depot on Osteogenesis and Healing of Fractures. J. Bone and Joint Surg., XVI, 176, Jan. 1934.

LERICHE, R., AND POLICARD, A.: The Normal and Pathological Physiology of Bone. St. Louis, The C. V. Mosby Co., 1928.

MACEWEN, SIR WILLIAM: The Growth of Bone; Observations on Osteogenesis. An Experimental Inquiry into the Development and Reproduction of Diaphyseal Bone. Glasgow, J. Maclehose & Sons, 1912.

MARTLAND, M., AND ROBISON, R.: The Possible Significance of Hexosephosphoric Esters in Ossification; The Bone Phosphatase. Biochem. J., XXI, 665, 1927.

MURRAY, C. R.: The Repair of Fractures. Minnesota Med., XIII, 137, 1930.

Delayed and Non-Union in Fractures in the Adult. Ann. Surg., XCIII, 961, 1931.

OLLIER, L.: Traité expérimental et clinique de la régénération des os et de la production artificielle du tissu osseux. Paris, Masson et fils, 1867.

PHEMISTER, D. B.: Personal communication, January 1934.

ROBISON, ROBERT: The Possible Significance of Hexosephosphoric Esters in Ossification. Biochem. J., XVII, 286, 1923.

WELLS, H. G.: Pathological Calcification. J. Med. Research, XIV, 491, 1905–1906.

Calcification and Ossification. Arch. Int. Med., VII, 721, 1911.

Chemical Pathology. Ed. 3. Philadelphia, W. B. Saunders Co., 1918.

ELECTROLYTIC DESTRUCTION OF BONE CAUSED BY METAL FIXATION DEVICES *

BY WALTER G. STUCK, M.D., SAN ANTONIO, TEXAS

In the treatment of fresh fractures it is often impossible to retain fragments in the reduced position without some sort of metal wire, screw, nail, plate, or band. Moreover, in the reconstructive surgery of old fractures, these devices are needed at times to secure bones in the desired position. Even when bone grafts are used for this purpose, some appliances must be utilized to anchor them. Thus, in certain fractures of the shoulder, or of the shaft of the humerus, or of the condyles of the tibia and femur, open operations are necessary to restore the fragments to their normal position, and metal appliances are usually required to hold the fragments in the desired relation to each other.

FIG. 1

C. B., male, aged thirty-four years. Old fracture of the upper end of the left tibia three months before admission, with non-union. On September 13, 1935, the fracture was explored. The fibrous tissue was removed, and a Parham band was applied. The roentgenogram, seven months later, shows erosion of the bone about the band and overgrowth of adjacent cortical bone. Considerable local tenderness and irritation were noted, but solid union of the fracture resulted.

It has been discovered clinically that most metals used in bone surgery cause erosion of the bone, as evidenced by roentgenograms, or soft-tissue reactions which produce tenderness and pain. Attempts have been made by many orthopaedic surgeons to avoid these unfavorable complications by using kangaroo tendon, beef bone, or strips of fascia lata instead of the usual metal appliances. Others have developed metal fixation devices which can be removed, after they have served their purpose, without a subsequent operation. Such substitutes have served fairly well, although there are still certain types of fractures where nothing can replace the use of metal fixation.

Until recently the mechanism of

*Read at the Annual Meeting of the Texas Railway Surgeons Association, Fort Worth, Texas, May 10, 1937.

FIG. 2-A

FIG. 2-B

Fig. 2-A: Y. E., male, aged ten years. Roentgenogram taken on November 5, 1935. The patient had sustained a fracture of the femur three weeks before, with marked overriding of the fragments.

Fig. 2-B: Roentgenogram after reduction, with fragments secured by two Parham bands and plate. In spite of perfect reduction, there was marked delay in the healing, which required removal of the bands and plate and fixation in a plaster cast for several months.

FIG. 3-A

C. E. P., male, aged forty-two years. On April 19, 1936, the patient sustained a fracture of the external condyle of the left humerus, with rotation of the fragment.

FIG. 3-B

Postoperative roentgenogram after reduction of the fracture and fixation with two copper-plated square steel nails. Solid bony union resulted, although much local irritation and tenderness were present, which necessitated removal of the nails.

FIG. 4-A

M. G., male, aged thirty-seven years. Fracture of the external condyle of the right tibia, with a small fragment of bone in the fracture line. The fracture was explored, the scrap of bone was removed, and the fragments were reduced.

FIG. 4-B

After reduction, showing perfect reposition of the fragments anchored by the author's method of removable crossed Kirschner wires. The wires were removed at the end of four weeks. Good function resulted.

the destruction of bone by metals has not been adequately understood. Zierold, Jones and Liebermann, Cretin and Pouyanne, Ménégaux and Odiette, to mention the more important investigators, have studied in detail the reaction of bone and soft tissues to various metals in an effort to discover the least toxic and more suitable materials. There is no uniformity in their recommendations of the best metal to use, and, in fact, their conclusions are more often contradictory.

In 1936, Venable, Stuck, and Beach,[1] at the Southern Surgical Association, reported the results of exhaustive experiments on the reaction of bone to different metals, which seemed to offer a clear solution to this puzzle. Chemical examinations of the bones and soft tissues revealed definite proof of electrolytic activity about screws of the metals commonly used in bone.

On the basis of previous animal experiments and of the clinical observations herein presented, it has been determined that, to avoid electrolytic destruction of bone when metals are used, the following facts must be recognized:

1. Pure metals of low toxicity (for instance, silver wire) are suitable if tensile strength is not required. Nevertheless, different pure metals should not be used in the same bone, since they will induce electrolytic reaction.

2. Alloys which contain iron are undesirable, since the local electrolysis (hysteresis) releases metallic ions in the blood stream and often produces toxic symptoms. Local reactions, furthermore, erode the bone adjacent to the alloy and annul its effectiveness.

3. Plated metal appliances are destructive to bone, since the plating

FIG. 5-A

FIG. 5-B

Fig. 5-A: C. B., male, aged twenty-two years. Fracture of the junction of the middle and upper thirds of the left femur, with malunion. On September 10, 1936, the fracture was explored. The fragments were replaced in their normal position. A beef-bone plate was applied and anchored with four vitalium screws. (This patient was operated upon before vitalium plates were available.)

Fig. 5-B: Roentgenogram of femur seven months after the operation, showing strong bony union. There is absolutely no bone absorption or reaction about the vitalium screws.

becomes cracked and allows dissimilar metals to be side by side in the electrolyte (body fluids) as is the case with a storage battery.

4. Alloys in which the constituent metals are adjacent in the E. M. F. (electromotive) series and which, therefore, possess slight differences of potential do not cause electrolysis and are not injurious to bone. Such an alloy of cobalt, chromium, and nickel (vitalium) has been cast into plates, screws, and nails which have been found to be completely non-injurious to bone. Roentgenograms taken months after the vitalium screws have been inserted reveal no necrosis of bone about the screws, as they do about all other commonly used metals, and there is no local pain or tenderness over the screws. Animal experiments likewise have shown that vitalium screws are tight in the bone months after their insertion, whereas other screws become loosened and ineffective. Finally, pathological examinations have revealed a minimum of reaction in the bone and soft tissues near these vitalium plates and screws.

1. VENABLE, C. S., STUCK, W. G., AND BEACH, ASA: The Effects on Bone of the Presence of Metals; Based upon Electrolysis. An Experimental Study. Ann. Surg., CV, 917, 1937.

SPINAL-CORD COMPRESSION ASSOCIATED WITH SCOLIOSIS

Report of a Case

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The fact that up to the present time only twenty-eight cases of paraplegia occurring as a complication of scoliosis have been reported indicates that this condition is rare. In a study of museum specimens showing markedly severe scoliosis it has been the common observation that the size of the spinal canal is adequate for the spinal cord without bone encroachment upon it. Paraplegia complicating scoliosis is new in the experience of the writer, and also has been unheard of by the many orthopaedic surgeons with whom he has conferred. Therefore, the author feels that the report of such a case is of value, particularly since there have been opportunities for observation which have not been heretofore recorded. The observations of others will be presented first in order that the reader may be informed on the subject beforehand and appreciate the unusual features of this case.

While paraplegia occurs as a complication of Pott's disease, it is usually attributed to the pressure of an abscess or the growth of tuberculous granulation causing pressure upon the cord. The writer, however, recalls having done laminectomies in two cases of Pott's disease, in which there was complete motor and sensory paralysis with loss of sphincteric control where no pressure of soft parts (abscess, granulations, or extradural mass of fat at the site of the angulation) was found. The dura and cord were found to be tightly stretched over an acutely angular bone deformity. In both of these cases the paralysis occurred during adolescence, and the site of the disease was in the upper dorsal region. It is noteworthy that both patients had had Hibbs fusion operations done many years before and, with the exception of the paraplegia, there was no indication of activity of the disease. One of these patients made a good recovery at the end of six months; the other one did not improve.

SURVEY OF THE LITERATURE

The reader will not be burdened by a detailed review of all case reports. For those who wish to consult the original articles, a bibliography is appended. Particular reference should be made, however, to the article by Mauclaire, who in 1913 was the first to record paraplegia occurring in scoliosis, and to the important work of Jaroschy, whose detailed studies are referred to in all subsequent reports. The publication by Valentin and Putschar is of particular interest because they give a complete report of the pathological findings of the spinal column and cord in the case of a nineteen-year-old boy who died with paraplegia associated with scoliosis.

FIG. 1

E. B., female, ten years of age. Roentgenogram on September 5, 1930, showing congenital scoliosis with wedging of vertebrae and fused ribs.

FIG. 2

Roentgenogram on February 5, 1932, showing progression of the deformity.

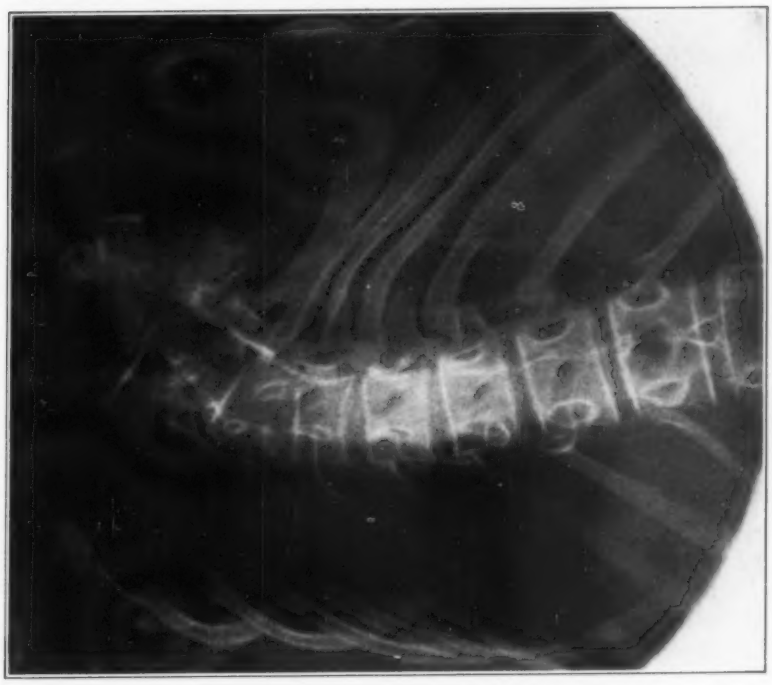

FIG. 4

Roentgenogram on June 16, 1936, two years after laminectomy and after attempted spine fusion. The patient is now seventeen years old and remains completely well.

FIG. 3

Roentgenogram on August 4, 1934, at the time of the appearance of paraplegia. Note the bayonet shape of the deformity.

ANALYSIS OF CASES PREVIOUSLY REPORTED

A review of the twenty-eight cases of paraplegia associated with scoliosis previously reported shows that the majority of the cases occurred during adolescence and were associated with either a long-standing congenital scoliosis (60 per cent.) or a severe paralytic scoliosis (40 per cent.). The apex of the curve was at or above the middorsal region. The level of the paralysis almost always corresponded to the highest point of the curve. In all cases the paralysis developed rapidly in intensity, but complete cessation of function with paralysis of the sphincters was present in only 33 per cent. of the cases reported. In eight of the recorded cases there was no record of treatment or of outcome. Of twenty-three cases where the sex was recorded, seventeen, or 74 per cent., were males. Root pain was present in only one case.

Laminectomy was done in ten cases, followed by a satisfactory response to treatment in six, partial recovery in three, and death in one case. Conservative treatment in ten cases resulted in a satisfactory response in only two, improvement in six, and no improvement in two. The dura was opened in all cases operated on except one, and it was the common experience that it was impossible to close the dura because of herniation of the cord through the opening. In most cases it was reported that the dura was under tension or tightly stretched over an angular bony prominence, but no mention is made of the removal of any spicule of bone or bony prominence. An extradural mass of fat was recorded in eight cases, but was not considered a factor in the causation of the paraplegia. Spinal puncture gives evidence of a subarachnoid blockage, and the injection of lipiodol visualizes the level of obstruction.

CASE REPORT

During the time that the patient in the following case was under treatment, the writer was unfamiliar with any previous occurrence of paraplegia associated with scoliosis.

E. B., a girl, ten years old, was first examined at the Gates Hospital for Crippled Children on September 5, 1930, because her parents had recently noticed that one shoulder was higher than the other. There was no complaint. Examination showed only a slight and abrupt lateral curvature at the upper dorsal region with the left scapula one inch higher than the right. The posture was poor. There was no asymmetry of the chest. Roentgenographic examination (Fig. 1) showed a congenital scoliosis at the upper dorsal region with wedge-shaped vertebrae and fused ribs. Postural treatment only was prescribed. The parents were told that this deformity must be watched, and were advised to bring her back for periodic observations and roentgenograms.

The patient was examined three months later and again at the end of six months. There was great improvement in posture, but the left scapula remained a little high as before. There appeared to be no increase in the scoliosis. At the end of eleven months, in August 1931, it was observed that the lower right ribs posteriorly were slightly prominent. Her posture was excellent. On February 5, 1932, seventeen months after the original examination, the prominence of the ribs on the right side was more marked. A roentgenogram (Fig. 2) on that date showed a moderate increase in the angulation. In view of this increase in deformity, shown only by the roentgenogram, a spine-fusion

operation was under consideration. However, this was not urged in view of there being no gross deformity of any consequence.

On June 16, 1933, it was noted that the patient had been growing quite rapidly. In June 1934, almost four years following the original examination, there was no increase in the gross deformity, the posture was good, there was no list, the shoulders were practically level, and the slight prominence of the lower ribs on the right side had not increased. There was no complaint. Postural exercises had long since been discontinued, and the patient was told to return for observation at the end of six months.

On July 25, 1934, she returned with the history of having had an acute attack of jaundice six weeks previously, and during the past month she had been having increasing difficulty in the use of her right leg. She had had no pain, no headache, and no disturbance in the control of the bladder or the rectum. Examination revealed a definite ataxia of the lower extremities and a positive Romberg sign. The ankle and knee jerks were increased and there was a bilateral Babinski reflex. There was no disturbance in sensation. The pupils were normal and there was no nystagmus. The upper extremities showed nothing abnormal. Examination of the back showed no increase in the gross deformity, and the posture was excellent.

On August 22, 1934, after one month in bed, both lower extremities had become completely paralyzed, and there was practically no control of the bladder or rectum. There was a complete loss of sensation to touch, and pain was present over both lower extremities and extending to the level of the fourth thoracic segment. The patient lay with the hips and knees in complete extension, and there were no mass reflexes. The tonicity of the muscles of the lower extremities was increased with very active knee and ankle jerks. The Babinski reflex was present on both sides. Roentgenographic examination (Fig. 3), at the time of the appearance of paraplegia, showed a wedge-shaped formation of the third and fourth thoracic vertebrae with the body of the fourth displaced markedly toward the left.

Since symptoms had rapidly progressed in spite of complete bed rest, laminectomy was advised. It was evident that there was a compression of the cord, and no spinal-fluid studies were made. At operation, on September 5, 1934, there was found a marked irregularity of formation of the spinous processes and arches of the third and fourth thoracic vertebrae. These arches were removed by means of rongeurs. The dura was exposed and was found to be pulsating normally. A ureteral catheter could easily be passed upward between the dura and the arches, meeting with no obstruction, but a definite obstruction was encountered below under the malformed arch of the fourth thoracic vertebra. Accordingly, this arch was removed. There was found at this level a definite bony constriction of the canal below which there was no pulsation of the dura. The lamina of the fifth thoracic vertebra was also removed, and below this the catheter could be passed easily with no obstruction. The cord appeared to be passing over an acutely angular bone deformity anteriorly. This surface was explored by dividing one root between ligatures, and the cord was then rotated. There was found a nodule of bone, apparently causing pressure on the anterior surface of the cord. This was removed. The nerve roots were not taut, and the dura did not appear to be under tension. Therefore, it did not seem that anything would be gained by opening the dura, especially since a definite bony constriction had been found and removed. The wound was closed tightly in layers, and the patient was returned to bed in good condition on a Bradford frame.

Postoperative recovery was rapid and complete. Three weeks after operation the patient regained normal control of the bladder and rectum, and there was a slight return of power in the use of the legs. Nine weeks after operation she had good active power in the use of both legs, and there was a return to normal sensation. The knee and ankle jerks were no longer definitely active, and the Babinski reflexes had practically disappeared.

The subsequent course has been uneventful, excepting for a subsequent operation on December 5, 1934, three months after laminectomy, when a bone graft from the tibia

was used to bridge the defect of the laminae. It was thought advisable to attempt stabilization, which would possibly prevent further displacement and recurrence of compression. Aside from a temporary return to spasticity, appearing three days after this secondary operation and lasting only for one week, recovery has remained complete.

It is now more than two years since operation and the patient remains completely well at seventeen years of age. The last roentgenogram (Fig. 4), taken on June 16, 1936, shows a remarkable offset of the bodies which has progressed since the attempted fusion operation.

DISCUSSION

The facts that this patient had been under observation for four years previous to the onset of the paraplegia, that the progression of the deformity was observed by a series of roentgenograms, and that the gross deformity was only slight are of particular interest. At operation the dura was not opened, and a mass of bone causing compression was found and removed, resulting in a rapid and complete recovery.

In regard to treatment of cord compression associated with scoliosis, it is difficult to establish any uniform method to be followed in every case. It would seem that conservative treatment on a frame or plaster shell should be tried first, in view of the reports of recovery following this line of therapy. However, if paralysis progresses during treatment, or if it does not shortly diminish, laminectomy is the method of choice. All writers who have operated are agreed that the dura should be opened and the cord decompressed. The decision to do this must rest on the judgment of the surgeon. If the dura is obviously stretched over a bony angle which cannot be removed, or if it is taut because of tension of nerve roots, it would seem best to incise the dura and leave it open or, possibly, to section the roots under tension to release traction on the cord. Where a projecting mass of bone is found exerting pressure, or where the arches are causing compression, it is obvious that the cause of the pressure must be removed. Exploration along the lateral and anterior surfaces of the cord must be carried out to determine the presence or absence of a projecting mass of bone or cartilage.

It would seem that degrees of spasticity less than those amounting to a paraplegia are more frequent, and at the first evidence of weakness or spasticity in the lower extremities coexisting with scoliosis the patient should be put to bed. It is also suggested that paraplegia occurring during adolescence, years after Pott's disease in early childhood has been arrested, is more likely caused by bony compression or a tightly stretched dura than a return to activity of the disease.

The occurrence of the case recorded here and of the cases reported in the literature would indicate that the patient with a congenital scoliosis should be carefully watched by roentgenograms, especially during the active-growth period of adolescence, for a progression of any vertebral displacement. It would also seem that a spine-fusion operation is indicated when this is demonstrated, even in the absence of an apparent increase in the gross deformity. This should not be undertaken, however, with the assurance that cord compression will be prevented, for, in

the light of our present knowledge concerning the anatomical abnormalities causing compression, a fusion operation will not preclude a subsequent appearance of these abnormalities. The writer is convinced that this was particularly true in two cases of cord compression which occurred during adolescence in which Pott's disease in early childhood had apparently been cured by a fusion operation. At operation a massive and solid bony fusion of the spine was found, and yet paraplegia occurred in the absence of any demonstrable activity of the disease.

SUMMARY

There have been twenty-eight cases of cord compression complicating scoliosis reported since 1913, and an additional case is reported here. This complication occurs in cases of long-standing scoliosis. Sixty per cent. of the reported cases were congenital in type and 40 per cent. were the result of infantile paralysis. The rapid-growth changes during adolescence and the inability of the spinal cord to accommodate itself to these changes are the likely explanation of the compression, since practically all of the reported cases of paraplegia occurred during this active-growth period. The paraplegia begins with no root symptoms and progresses rapidly. While recovery has followed conservative treatment, laminectomy has resulted in a higher percentage of cures. Prognosis with laminectomy appears to be good. The question of spinal fusion is discussed, but no conclusion is formulated as to whether or not this operation will prevent cord compression.

BIBLIOGRAPHY

BERGMANN, K.: Two Cases of Scoliosis with Paraplegia. Acta Chir. Scandinavica, LXIV, 222, 1928.

BORCHARDT, M.: Kyphoskoliose und Rückenmark. Schweizerische med. Wchnschr., LXIV, 613, 1934.

COLLIER, JAMES: Case of Paraplegia in Scoliosis. Proc. Roy. Soc. Med. (Sect. Neurol.), XVIII, 8, 1925.

ELMSLIE, R. C.: Two Cases of Scoliosis with Paraplegia. Proc. Roy. Soc. Med. (Sect. Orthop.), XVIII, 25, 1925.

GROBELSKI, M.: Kompressionslähmung des Rückenmarks bei Skoliose. Ztschr. f. orthop. Chir., LVII, 220, 1932.

JAROSCHY, W.: Über Spätschädigungen des Rückenmarks bei kongenitaler Skoliose und ihre operative Behandlung. Beitr. z. klin. Chir., CXXIX, 348, 1923.

———— Über Spätschädigungen des Rückenmarks (Kompressionsmyelitis) bei schweren Skoliosen. Beitr. z. klin. Chir., CXLII, 597, 1928.

KLEINBERG, S.: Structural Scoliosis Complicated by Paralysis of the Lower Limbs—Report of a Case. J. Bone and Joint Surg., V, 104, Jan. 1923.

LEHRNBECHER, A.: Operation oder redressierendes Vorgehen bei skoliotischer Markkompression? Zentralbl. f. Chir., LV, 1606, 1928.

MAUCLAIRE: Scoliose cervicale primitive avec paraplégie intermittente. Trans. Internat. Cong. Med. (Subsect. VII (a), Orthop., Pt. II, p. 91), 1913.

MCKENZIE, K. G.: Paraplegia Associated with Congenital Scoliosis. Report of a Case. Arch. Surg., XV, 222, 1927.

MENARD, L.: Deux cas de paraplégie dans la scoliose. Description. Traitement. Etiologie. Rev. d'Orthop., XVIII, 759, 1931.

Moe, J. H.: Paraplegia Secondary to Scoliosis. Proc. Clin. Orthop. Soc., 1933.

Ridlon, John: Report of Two Cases of Scoliosis Accompanied by Pressure Paralysis of the Lower Limbs. J. Am. Med. Assn., LXVII, 803, 1916.

Sachs, Ernest: An Unusual Case of Paraplegia Associated with Marked Gibbus and a Localized Collection of Fat at the Site of the Gibbus. J. Bone and Joint Surg., VII, 709, July 1925.

Siebner, M.: Zur Behandlung des Kompressionslähmung des Rückenmarks bei schwerer Skoliose. Chirurg, II, 663, 1930.

Thomas, André, Sorrel, E., et Sorrel-Dejerine: La paraplégie scoliotique. (A propos d'un cas suivi d'autopsie.) Presse Méd., XLI, 1542, 1933.

Valentin, B., und Putschar, W.: Zur Klinik und Pathologie der Kyphoskoliosen mit Rückenmarksschädigung. Ztschr. f. orthop. Chir., LVII, 245, 1932.

Viets, H. R., and Clifford, M. H.: Paraplegia Associated with Non-Tuberculous Kyphoscoliosis; A Case Report and a Survey of the Literature. New England J. Med., CCVI, 55, 1932.

TRAUMATIC DEGENERATIVE FIBRILLATION OF THE PATELLA

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Degenerative fibrillation of the patella as a disease entity was first described in this country in 1933 by Kulowski who reported three cases. In 1935 two cases were reported by Slowick, and no other reference to this condition is to be found in the English literature.

Since 1932, the writer has collected five cases, all of which came to operation and in which satisfactory recovery has been made.

Degenerative fibrillation of the patella occurs as a circumscribed area of fissuring and erosion of the articular surface of the patella with loose fibrillae arising from the edges of the fissures. The contiguous portions of the condyles of the femur also show erosion, but seldom fibrillation. In one case the cartilage of the femoral condyle was raised above the surface, so as to fit into a fissure on the patella. Pain referable to the patella is a constant symptom, and most characteristic is the tenderness to patellar pressure in the flexed position. There may be associated with the patellar lesion other pathological conditions such as derangement of the semilunar cartilages, synovitis, joint mice, or slipping patella. Roentgenograms show very little, even with air distention of the joint.

Conservative treatment such as physiotherapy over a long period of time, or the use of immobilizing apparatus even in mild cases, has not brought relief from pain and sense of weakness in the affected joint.

Each of our cases eventually required arthrotomy and removal of the fissured and fibrillated cartilage, together with correction of concomitant lesions when present. In each case a parapatellar incision was used and the patella was everted. The cartilage was shaved off smoothly with a sharp knife, leaving only a transparent film of cartilage covering the bone.

All of the patients made complete recovery and were entirely relieved of pain and disability.

The following cases are typical of this disease. The first illustrates the fact that concomitant lesions are not necessary to produce the fibrillation but, rather, that trauma is the important factor.

CASE 1. E. B., a white female, aged thirty-eight, complained of pain in the right knee following a fall six years earlier. The pain had increased in severity and was very disabling.

Examination showed the right knee to be slightly swollen with a slight amount of joint fluid present. The range of motion was normal. No symptoms were elicited other than pain when pressure was made over the patella. Stereoscopic roentgenographic examination, with air inflation, revealed no pathology. Fluid aspirated from the joint showed nothing pathological. All conservative measures were tried without relief.

On October 8, 1932, an exploratory arthrotomy was performed. The only abnormal findings were fissuring and fibrillation of the cartilage of the patella, and a small nubbin raised above the surface of the cartilage on the femoral condyle which came into contact

FIG. 1

Case 2. Section showing minute cysts in ground substance.

with the fissure of the patella. The fibrillated cartilage was shaved off nearly to the bone, and the joint was closed.

There has been complete relief from pain with no recurrence to date.

CASE 2. Y. S., a white female, aged forty-six, was admitted to the Hospital for Joint Diseases on the Service of Dr. Kleinberg on May 11, 1933. She gave a history of an injury to the left knee eight months previously. Examination showed nothing of interest save marked tenderness to pressure along the medial joint line and a pronounced limp on walking.

An exploratory arthrotomy was done by Dr. Kleinberg on May 13, 1933. The cartilage on the patella was found fibrillated and fragmented. The medial meniscus was loose and was removed. There was fibrillation of the cartilage in the notch between the condyles. This fragmented cartilage was removed and the joint was closed.

The patient made an uneventful recovery and was completely relieved.

FIG. 2

Case 3. Appearance more suggestive of fibrocartilage than hyaline cartilage, due to irritative proliferation.

The pathological report by Dr. Jaffe stated that section of the cartilage removed from the under surface of the patella showed some minute cysts in the ground substance.

CASE 3. E. R., a male, aged seventeen, was admitted on February 8, 1933 to the Hospital for Joint Diseases on the Service of Dr. Kleinberg, with a history of pain, following a day of sport, and a sensation of the presence of a foreign body in the left knee. Roentgenographic examination revealed a sliver of calcified material between the patella and the femur.

Arthrotomy, on February 9, 1933, by Dr. Kleinberg revealed an area of one square centimeter on the under side of the patella bunched up and projecting into the joint. The mass consisted of fragmented and fissured cartilage which was elevated from the underlying bone. This was shaved off and a loose medial meniscus was removed. The wound was closed and the patient made an uneventful recovery.

The pathological report by Dr. Jaffe stated that the section had everywhere the appearance of fibrocartilage rather than hyaline cartilage. It represented irritative proliferation of the surface layers of articular cartilage, as in chronic arthritis, apparently by the action of the perichondrium. Following such proliferation, the new tissue had become detached.

CASE 4. A. L., a female, aged thirty-six, was admitted to the Hospital for Joint Diseases, on November 13, 1934. on the Service of Dr. Kleinberg, with a history of injury to the right knee, which had caused pain and disability. Two years previously a meniscectomy had been performed on the right knee to relieve a similar condition. Since pain and disability had persisted, the patient was advised to submit to reoperation.

Roentgenographic examination on the same day by Dr. Pomeranz showed moderate narrowing of the joint space internally with marginal hypertrophic changes. Slight

FIG. 3

Case 4. Fibrillated cartilage from articular surface of patella.

lipping was present on the posterior surface of the patella. There was no atrophy or sclerosis.

An exploratory arthrotomy, performed by Dr. Kleinberg on November 14, 1934, revealed a loose body in the joint, and fibrillation of the articular cartilage of the patella and the internal femoral condyle. The external semilunar cartilage was removed. No other pathology was found. The articular cartilage was shaved off and the knee was closed. Uneventful recovery followed.

Microscopic examination of the articular cartilage removed from the patella showed fibrillated articular cartilage.

CASE 5. E. A., a white male, aged twenty-three, was admitted to the Hospital for Joint Diseases on the Service of Dr. Kleinberg on July 5, 1932, because of pain and slipping of the patella. The onset had occurred ten years before, following a severe fall.

The patient walked with a marked limp on the right side; when the knee was flexed, the patella was seen to slip to the outer side and when the knee was extended it slipped back into position. The patella was hypertrophied and the condyle on the outer side felt smaller than that on the inner. Roentgenographic examination showed similar findings, with the additional notation of the presence of several calcified bodies.

Arthrotomy, performed on July 8, 1932 by Dr. Buchman, revealed several loose bodies; these were removed. The cartilage on the inner side of the patella was fibrillated and stringy. This was shaved off close to the bone. The insertion of the patellar tendon was transplanted medially and the external condyle was elevated.

The patient made a very satisfactory recovery and now has no limp, weakness, pain, or disability.

SUMMARY

The five cases of fibrillation of the patella which have been reported are illustrative of a lesion produced by trauma. When not masked by other lesions of traumatic origin, such a lesion gives the characteristic symptom of persistent pain over the patella, which is not relieved until the fibrillated cartilage is removed.

The author wishes to express his appreciation to Dr. S. Kleinberg for the opportunity to study and present several cases treated at the Hospital for Joint Diseases.

REFERENCES

KULOWSKI, JACOB: Chondromalacia of the Patella. Fissural Cartilage Degeneration; Traumatic Chondropathy: Report of Three Cases. J. Am. Med. Assn., C, 1837, 1933.

SLOWICK, F. A.: Traumatic Chondromalacia of the Patella. Report of Two Cases. New England J. Med., CCXIII, 160, 1935.

DIASTASIS OF THE SUPERIOR TIBIA COMPLICATED BY GANGRENE

Study of a Case

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This case is presented because of its rarity. In a thorough review of the literature we have been able to find only one reference concerning separation of the superior epiphysis of the tibia,—an article by Gibson who stated that Roberts and Kelly in 1916 had noted that only twenty-six cases of diastasis of the tibia had been recorded. Homans and DaCosta in their text-books state that separation of the superior tibial epiphysis is quite rare, and, as far as we have been able to determine, this is the only case of this nature that has been reported since Gibson's article in 1923. In a review of the records of over 2,000 cases seen in the past ten years on the Fracture Service of the Hurley Hospital, no similar case has been found.

The complication of gangrene following fractures, exclusive of gas-bacillus infection, is likewise unusual. Dodd, in a thorough review of the literature regarding gangrene following fractures, found only thirty-one cases reported between 1850 and 1914, and to this group he added a series of ten cases. Of the thirty-one patients whose cases were recorded in the literature, twenty-seven were males and four were females. Eleven of the cases occurred in males between the ages of sixteen and thirty. Amputations were performed in all but four cases. Complete data were available in twenty-four cases. Dodd reports on these as follows: "Eleven recovered and thirteen died, so that there is apparently a heavy mortality of 54 per cent." Gregora, who has studied this phase of surgery, found only four occurrences of gangrene in 606 fractures, and he stressed largely the steps to prevent gangrene and to save the extremity involved. Further evidence of the scanty information which we have on this subject was given by Ormsby in 1911, who prefaced a report of two cases as follows: "The complication of gangrene is an uncommon one, if I am to judge from the meager references to it to be found in the literature at my command."

CASE REPORT

E. W., aged sixteen years, a schoolgirl, was in an automobile accident on November 17, 1936. She was thrown forward on her knees and the right knee apparently struck an elevation in the floor of the car. When first seen, the patient was conscious and well oriented, and the only positive physical findings were in the right knee. It was noted that the leg below the knee was displaced posteriorly from 50 to 75 per cent., although the knee retained the usual amount of flexibility. The bony prominences of the superior tibia, as well as the pulsation of the popliteal artery, were palpable in the popliteal space.

The leg and foot were not measurably swollen, and the foot was warm, although the dorsalis pedis and the posterior tibial arteries were not palpable. Roentgenographic examination (Fig. 1) revealed a separation of the proximal tibial epiphysis and complete displacement of the diaphysis posteriorly and slightly to the medial side, with a complete avulsion of the tibial tubercle. The fibula was not involved.

The fracture was immediately and easily reduced under gas anaesthesia, and a light plaster-of-Paris dressing was applied. The foot remained warm, although pulsation of the arteries did not return, and a check-up roentgenogram (Fig. 2) revealed a restoration of the proximal epiphysis to an almost normal position, although it remained displaced slightly anteriorly and laterally.

Within twenty-four hours, however, the patient began to complain of numbness in the toes and soreness of the leg. The toes were becoming cyanotic, and the cast was immediately bivalved. At the end of ninety-six hours, the leg was noted to be quite swollen and painful, and the toes were definitely cool. The pain, swelling, tenderness, coolness, and cyanosis were increasing, the calf had become whitish and shiny, and, in view of the increasing discoloration and beginning anaesthesia of the foot, it was felt that a decompression of the popliteal space was indicated.

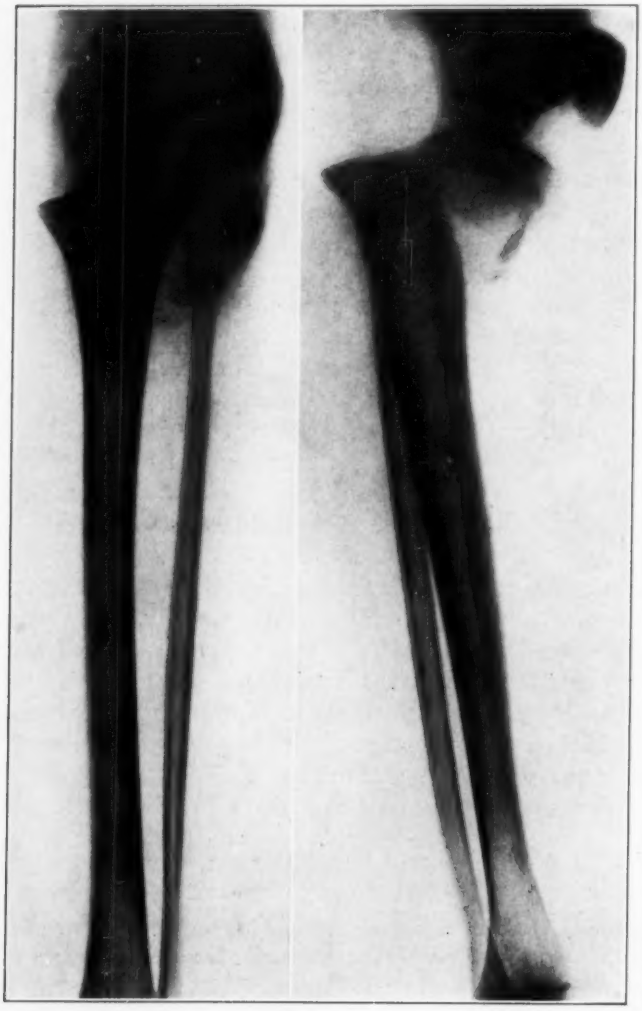

FIG. 1

Condition on admission. Note the posterior displacement of the tibial diaphysis and the avulsed tibial tubercle.

The popliteal space was entered medially, and a large hematoma was removed. The popliteal artery was noted to be pulsating, and there was considerable oedema of the surrounding tissues. In addition, six longitudinal incisions, about six inches in length, were made over the leg laterally, anteriorly, and posteriorly, through the fascia, and into the muscles; these were left open and a drain was placed in

the popliteal space. The leg was subsequently dressed and immobilized in a pillow splint. Observation continued, and the foot became a bit warmer, although, in general, the condition of the leg grew progressively worse. The toes gradually became stiff, blackened, and cold, with considerable shriveling; the calf remained swollen, the long incisions were discharging seropurulent material, and the fascial planes were showing grayish discoloration; complete anaesthesia existed over the entire foot. (See Figures 3 and 4.) In view of the patient's weakened condition (temperature from 100 to 103 degrees daily from November 18, 1936 to December 3, 1936), supportive measures were carried out, which included the indirect transfusion of 500 cubic centimeters of citrated blood on three occasions. However, the patient's condition became steadily worse, and a midthigh amputation was decided upon and done as a life-saving procedure on December 3, 1936, under nitrous-oxide anaesthesia. This procedure was preceded by a third

FIG. 2

After reduction. Note the restoration of the proximal tibial epiphysis to an almost normal position.

FIG. 3

Third postoperative day. Note the discoloration of the leg with medial and anterior incisions.

FIG. 4

Third postoperative day. Note the discolored leg, foot, and toes, with shriveling of the latter.

transfusion of 500 cubic centimeters of citrated blood.

The patient's temperature immediately returned to normal and remained there throughout the postoperative course which was entirely uneventful. The wound at the stump healed by primary intention, and the patient was discharged in excellent condition on December 20, 1936.

DISCUSSION

The bifurcation of the popliteal artery is anchored by the fibrous arch of the soleus, by the passage of the anterior tibial artery over the interosseous membrane, by its proximity to the fibula, and by the origin of small anastomotic branches to the knee joint. The comparatively intimate association of the bifurcation with the neck of the fibula has been noted,—*i.e.*, on the inside of the neck of the fibula there is a slight groove which is made by the anterior tibial artery as it passes from behind to the front part of the leg. This emphasizes the vulnerability of the artery in fractures in this region of the fibula.

The anterior and posterior tibial arteries are also close to the fibula, particularly in the upper third of the leg, and furthermore they lie on, or are covered by, aponeurosis,—in other words, the anterior and posterior tibial arteries are in reality closer to the fibula than to the tibia. Muir's case of a fracture of the upper third of the fibula followed by gangrene illustrates this point.

The pathological report of the case which has been described was as follows: "The specimen consists of an oedematous leg (right), which has been amputated at the middle third of the thigh. The toes show a dry gangrene. There are longitudinal incisions in the popliteal space and in the

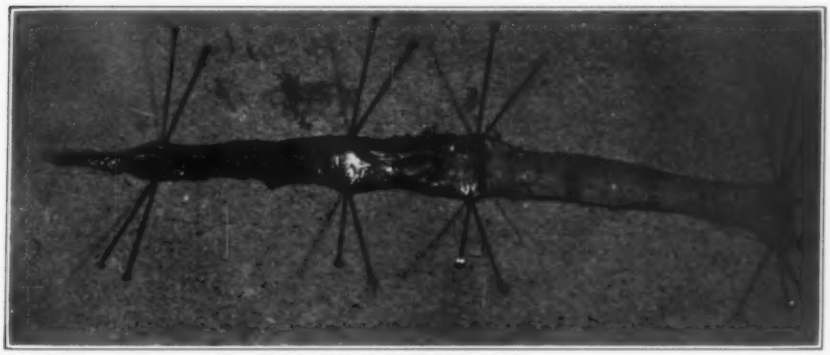

FIG. 5

Dissected popliteal artery. Note the constricted area proximal to the bifurcation with discolored thrombosis above the narrowed lumen.

upper and middle thirds of the calf. There is a serosanguineous exudate from these incisions.

"The distal end of the femoral artery was found and dissected down to the bifurcation of the popliteal into the anterior and posterior tibial arteries. About two centimeters above this bifurcation there was a marked area of constriction and just above this was a firm, discolored area which was two and one-half centimeters in length. On sectioning the artery throughout its entire length, this discolored region was found to be an area of thrombosis with a distal constriction of the popliteal artery. [See Figure 5.]

"On further dissection of the leg, the entire venous system was so necrotic that it was impossible to dissect out the veins as such. The popliteal space was completely filled with old clotted blood which extended anteriorly to the interosseous septum. All of the tissues of the leg were oedematous and showed beginning necrosis."

In this case, the postreduction diagnosis was obvious, inasmuch as the usual signs of interruption of blood supply (absence of arterial pulsation, anaesthesia, swelling, etc.) were present. The time of onset of gangrene is apparently on the third to the sixth day, ordinarily on the fourth. As noted, the gangrene began to develop in this case on the third day. The actual etiology of the vascular interruption in this case apparently was a venous oozing at the site of the original trauma, followed by a subsequent thrombosis of the artery (ante-amputation diagnosis).

SUMMARY AND CONCLUSIONS

This dramatic case presented three phases in its management: (1) a reduction of the fracture-dislocation, which was accomplished easily and satisfactorily; (2) efforts at saving the leg by the decompression procedures previously described; (3) the imperative necessity of saving the patient's life by amputation.

If a similar case should present itself, we feel that this same manage-

ment would be resorted to, with the possible exception of earlier intervention in the second and third phases.

REFERENCES

DaCosta, J. C.: Modern Surgery, General and Operative. Ed. 10. Philadelphia, W. B. Saunders Co., 1931.

Dodd, Harold: Gangrene Following Fractures (Excluding Gas Gangrene). British J. Surg., XXII, 246, 1934–1935.

Gibson, Alexander: Separation of the Upper Epiphysis of the Tibia. Ann. Surg., LXXVII, 485, 1923.

Gregora, H.: Extremitätengangrän nach subkutaner Gefässruptur durch stumpfe Gewalt. Beitr. z. klin. Chir., CXL, 199, 1927.

Homans, John: A Textbook of Surgery. Ed. 2. Springfield, Illinois, Charles C. Thomas, 1932.

Muir, J. B. G.: Traumatic Gangrene of the Foot Complicating a Fractured Fibula. Lancet, II, 321, 1924.

Ormsby, O. B.: Fracture of the Femur Complicated by Gangrene of the Leg. Internat. J. Surg., XXIV, 238, 1911.

FURTHER OBSERVATIONS ON TREATMENT OF FRACTURE OF THE CARPAL SCAPHOID (NAVICULAR)

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During the past ten years the problem of treatment of fracture of the carpal scaphoid has been receiving increased attention. In 1928, Adams of Boston introduced the use of the bone graft and not long afterward Murray of Toronto suggested the present-day technique,—namely, the use of the bone peg. A few years ago a study of fractures of the carpal scaphoid treated at the leading industrial clinics in Boston showed that the results obtained left much to be desired. In 1934, the author reported his experience with both the bone-graft and the bone-peg operations. Sufficient time has now elapsed to show definite end results over a period of from four to seven years in the cases reported at that time. It is the purpose of this paper to record the final results in these cases and to present other representative cases.

During 1934, 1935, and 1936, 100 patients with fracture of the carpal scaphoid were treated in the Out-Patient Department of the Boston City Hospital. Six of these were females, and 48 per cent. of them were twenty years of age or under. We are, therefore, dealing with a condition that affects young people and one that should be treated early and correctly.

TREATMENT

Sprained wrists in which the pain is sufficiently severe or localized to make one suspicious of a fracture of the scaphoid should be protected from the start, either by an anterior wooden splint or by a leather wrist strap large enough to include the hand and a good part of the forearm. If later roentgenograms show a fracture, suitable treatment will have been instituted early and properly maintained by the leather wrister. A sprained wrist which does not clear up in a month's time should be x-rayed again with a possible fracture of the scaphoid in mind. If this is done, further trouble will be saved in many cases. Often roentgenographic examination will be negative immediately following the injury, only to show a fracture a month later. Many fresh cases show a very fine fissure fracture which is often overlooked by physicians unfamiliar with it and which, untreated, may show a heavy line of absorption within a very few months. The following case is illustrative of this condition.

CASE 1. T. C., male, aged thirty-four, a laborer, injured his wrist on May 20, 1932, while lifting a roll of paper. Roentgenographic examination (Fig. 1-A) showed a fissure fracture, and the patient was treated with anterior and posterior splints for from four to five weeks, followed by baking and massage. He was out of work for approximately four months. In July 1933, he was reexamined because of the condition of his wrist,—

namely, pain, weakness, inability to push or to flex the wrist dorsally. The roentgenogram taken at that time (Fig. 1-B) showed marked absorption. The patient was operated upon in another clinic where an inlay graft was used. The wrist was immobilized for four weeks and the patient was allowed to return to work in five weeks. The end result was very poor, due undoubtedly to his returning to work too soon and too brief a period of splinting.

FIG. 1-A

Case 1. T. C. May 20, 1932. Fissure fracture of scaphoid.

FIG. 1-B

Case 1. T. C. July 1933, fourteen months later, showing line of absorption.

If the diagnosis of a fracture has been made in a fresh case, the treatment should consist of immobilization in plaster and rest, with the hope that bony union may occur. There is considerable difference of opinion as to just how the hand should be held at this time; many use the cock-up position, with radial deviation and with slight abduction of the thumb, while others use the reverse,—slight volar flexion with radial deviation. From personal observations and work with Dr. F. J. Cotton and Dr. D. D. Berlin, we have found it best to use dorsal flexion.[3] In these cases, the plaster-of-Paris cast is used instead of the ordinary cock-up splint. This immobilizes the wrist, does not require adjustment when properly applied, and ensures the patient of a continuance of the treatment. Often, with the metal cock-up splint, the patient gives up the treatment at the end of two or three weeks and is never seen again. In this way, one not only loses the patient, but the splint as well. Regardless of how it is obtained, immobilization should be maintained for at least six weeks, followed by baking and massage for a few weeks. Too much emphasis cannot be placed on the need of six weeks' immobilization. Less time, in our opinion, is entirely inadequate.

The cast is applied in the cock-up position with slight radial flexion

to include the palm of the hand and the base of the thumb, but this does not limit the motion of the fingers. Some feel that it is better to include in the cast the distal joint of the thumb with marked abduction, thereby assuring better and closer approximation of the fragments. Following the removal of the cast, a straight splint may be applied for a few days, after which a flannel bandage is substituted and motion is started at once.

Most of these cases, if seen within forty-eight hours following trauma, will do well under this routine. The mistake most commonly made is the shortening of the period of absolute rest. In fresh cases, treated as described, if the results are not satisfactory at the end of four months—and most of them are at the end of three months—they are very apt to grow more and more unsatisfactory. There is no harm in waiting a while longer, but in our experience these cases will not improve and it will be necessary to resort to an operation. We do not feel that enough of these cases, either treated or untreated, are operated upon.

In the second group of cases where there is marked separation of the parts, we believe that it is possible to reduce the fracture and to peg the fragments instead of resorting to operative removal. This type of fracture, usually associated with a crushing of the soft tissue, is very rare.

In the third group of cases the wrist is crippled by months of use, with the resultant pain and weakness so frequently seen. This group represents the cases, usually untreated or poorly treated, that have gone on to malunion with bone formation along the radial styloid. (See Figure 2.) If the patient is engaged in an occupation requiring the constant use

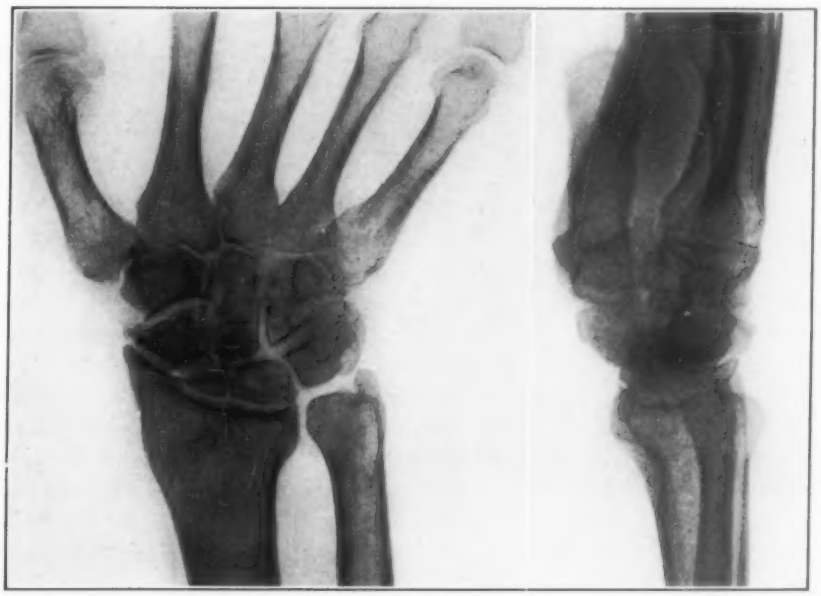

FIG. 2

Old fracture with elongation of styloid.

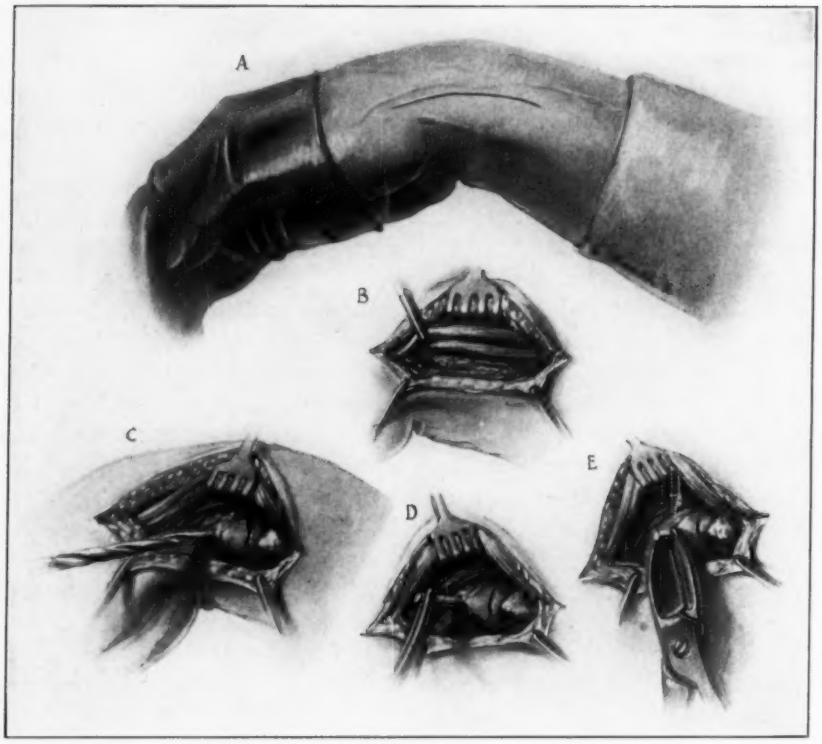

FIG. 3

Operative technique.

of the wrist, this injury leaves him almost totally disabled from the standpoint of earning his living along the lines to which he is accustomed. The following operation is recommended for this type of case.

OPERATIVE TECHNIQUE

The best incision is the lateral one made midway between the palmar and the dorsal aspects of the radius, usually from one and one-half to two inches in length, avoiding the palmar side of the wrist because of the danger of hemorrhage, with retraction of the tendons upward. (See Figures 3, *A* and 3, *B*.) The styloid of the radius is always used as a landmark for locating the scaphoid. Much has been written about operating on the wrong bone, and many mistakes have been made and continue to be made —such as removing the semilunar, drilling the trapezium, etc.—but these errors can be avoided by making use of the radial styloid. Another absolute check is to observe the fracture line in the scaphoid which is obvious through this incision. After the joint has been opened, the wrist is then placed in acute palmar flexion with some radial deviation (thereby placing most of the scaphoid in the middle of the wound) and held there by an assistant with the aid of a sandbag placed under it. A drill hole, a quarter of an inch in diameter, is made according to the technique of

Murray. (See Figure 3, *C*.) In drilling this hole, care should be exercised not only in regard to the direction of the hole but also to the depth. Occasionally the drill runs over into the semilunar. The bone peg used to stabilize the fragments and to stimulate union is taken from the tibia

FIG. 4-A

Case 2. D. A. L. April 7, 1930.

FIG. 4-B

Case 2. D. A. L. January 25, 1937. Fibrous union.

FIG. 5

Case 3. P. O. January 21, 1937. No union.

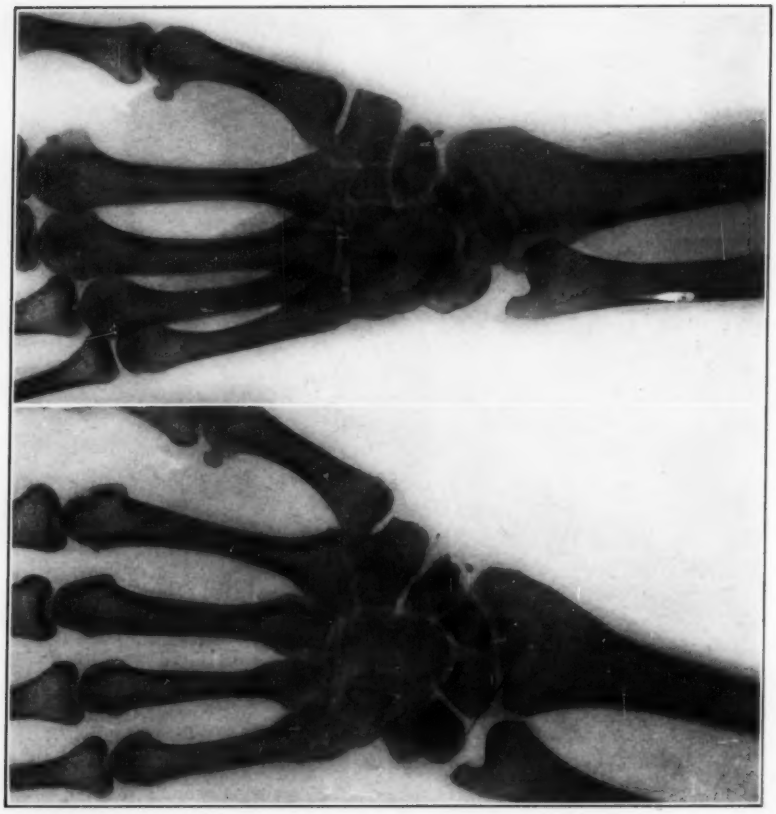

FIG. 6-B

Case 4. H. S. B. January 30, 1937. Fibrous union.

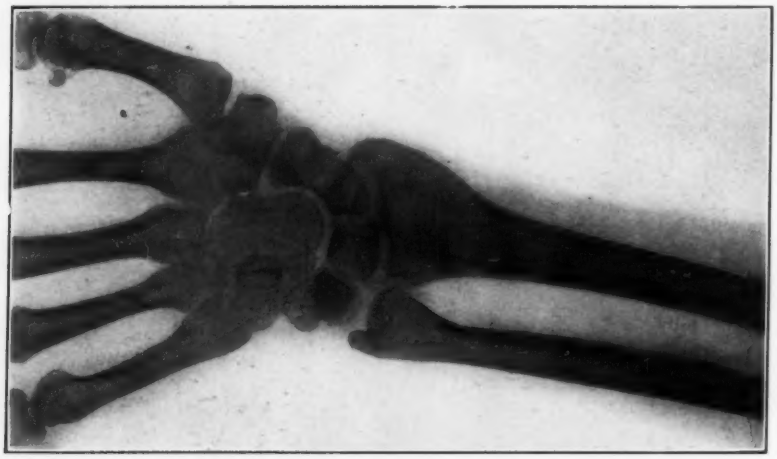

FIG. 6-A

Case 4. H. S. B. April 12, 1934.

rather than from the radius and is fitted with rongeurs to the drill hole. (See Figure 3, *D*.) After this peg has been tapped in as far as desired, the excess is cut away with bone forceps and the wound is sutured in layers. (See Figure 3, *E*.)

In two cases roentgenographic examination, together with clinical signs and symptoms, gave evidence of a fracture, but operation failed to reveal it. Both of these cases were treated in the usual manner,—namely, drilling and pegging. The results were excellent, with complete relief from symptoms.

CASE REPORTS

CASE 2. D. A. L., male, aged forty-seven, a chauffeur-mechanic, fell in August 1929, injuring his wrist. He wore a leather splint for two months without relief. In February 1930 he complained of pain, weakness, and inability to push. An inlay-graft operation was performed in April 1930, and the wrist was immobilized in plaster for ten weeks. Figure 4-A shows the condition before operation and Figure 4-B, taken in January 1937, shows the end result. This appears to be a fibrous union. Clinically, except for a slight limitation of dorsal flexion, it is an excellent result.

CASE 3. P. O., male, aged seventeen, a student, injured his wrist while playing football in November 1931. He had little or no treatment. A bone-peg operation was performed in July 1932, and a plaster cast was applied for eight weeks. Figure 5 shows the

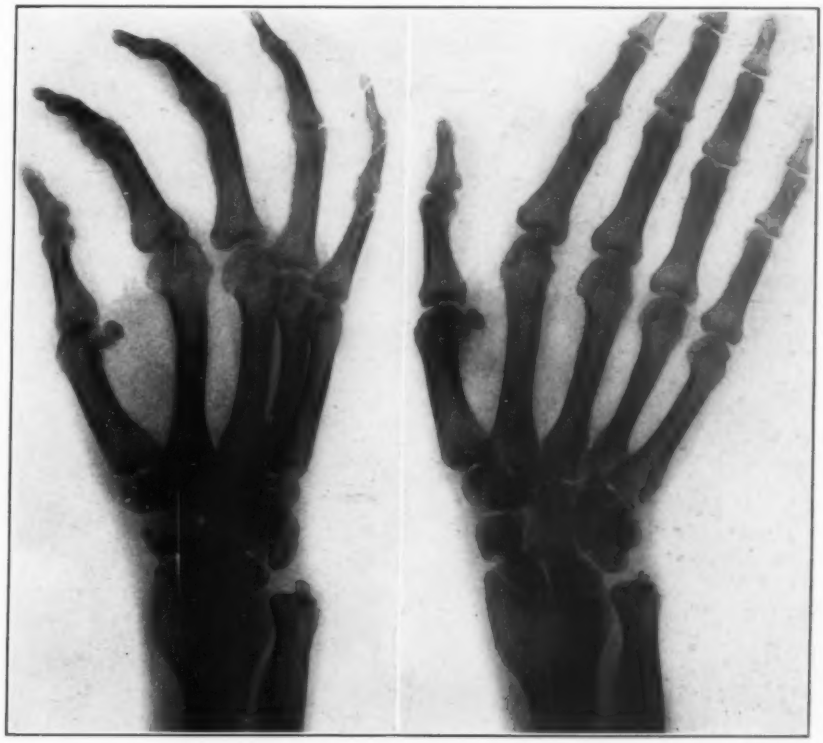

FIG. 7

Case 5. G. C. January 19, 1937. Bony union.

condition on January 21, 1937. From the anteroposterior view, one would believe that there was bony union, but the oblique view shows a black line between the fragments, or absolutely no union. Dorsal flexion was limited; otherwise, an excellent clinical result was obtained.

CASE 4. H. S. B., female, aged eighteen, fell and injured her wrist. Eight months later, in April 1934 (Fig. 6-A), a bone-peg operation was performed. The wrist was immobilized in plaster for seven weeks, followed by an anterior splint for ten days.

FIG. 8-A

Case 6. F. T. March 22, 1935. Bone peg inserted into semilunar through scaphoid.

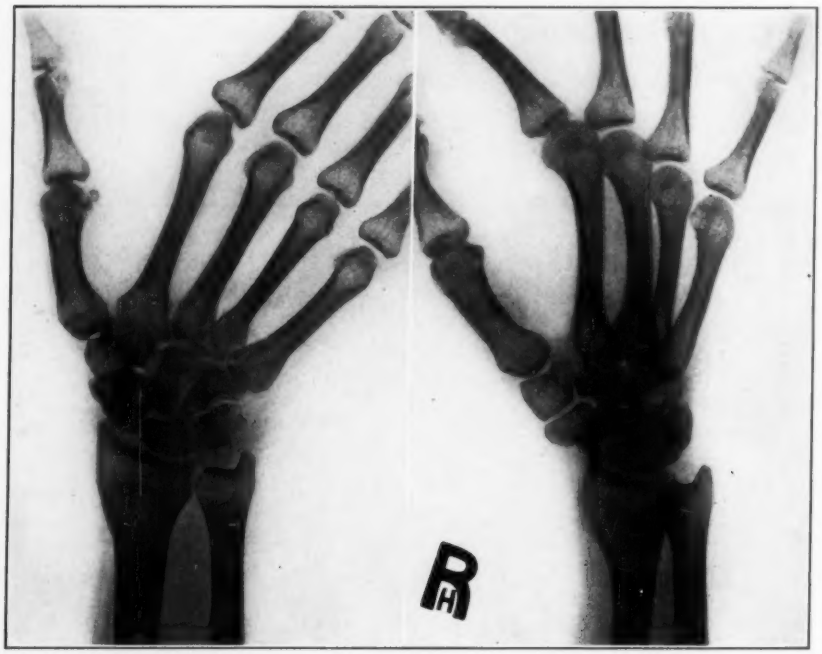

FIG. 8-B

Case 6. F. T. January 22, 1937. Bony union.

FIG. 9

Case 7. A. D. End result following operative removal of scaphoid.

Roentgenographic examination in January 1937 (Fig. 6-B) showed fibrous union. The clinical result is excellent.

CASE 5. G. C., male, aged twenty, fell while roller-skating, landing on his right hand. This was followed by a moderate amount of pain in the wrist. He was told at the Relief Station that there was no fracture. During the following year he continued to complain of pain on motion, especially marked when playing baseball. A bone-peg operation was performed on August 15, 1936. Roentgenographic examination on January 19, 1937 (Fig. 7) showed bony union. The clinical result is excellent.

CASE 6. F. T., male, aged twenty-one, injured his wrist while diving. Six months later, on March 22, 1935, a bone peg was inserted into the semilunar through the scaphoid. (See Figure 8-A.) On January 22, 1937, a check-up roentgenogram (Fig. 8-B) showed apparent union of the scaphoid and the semilunar. An excellent clinical result was obtained.

CASE 7. A. D., male, aged thirty-five, fell and fractured the carpal scaphoid. The fracture was inadequately treated and a chronic condition developed, necessitating the removal of the scaphoid. (See Figure 9.) Clinically, a reasonably good result was obtained, but there was a marked change in the anatomy of the wrist.

CASE 8. E. B., male, aged twenty-six, fell backward on April 23, 1934, sustaining a bilateral fracture of the carpal scaphoid, with dislocation of the proximal row of carpal bones. (See Figure 10-A.) On May 1, 1934, by means of Soutter traction under ether anaesthesia for fifteen minutes and a Thomas wrench, the fracture was reduced. (See Figure 10-B.) The wrist was placed in anterior and posterior splints for five days and later in a cock-up plaster cast for nine weeks. This patient disappeared and no further roentgenograms were obtainable. A satisfactory result is said to have been obtained.

SUMMARY

In summarizing, we wish to stress the following points:

1. In all suspicious cases, and in checking the end results for union, the oblique view is most important.

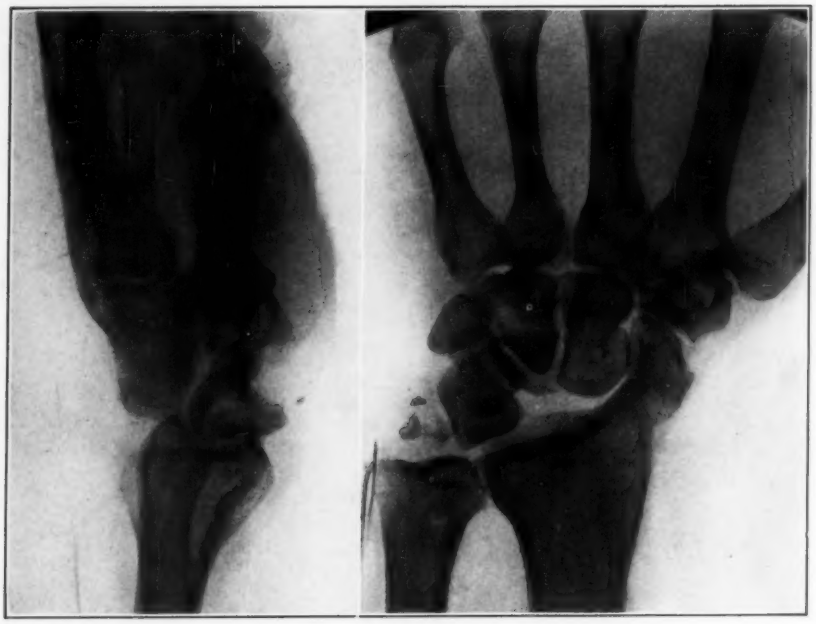

FIG. 10-A

Case 8. E. B. April 23, 1934. Dislocation of first row of carpal bones, with fracture of scaphoid.

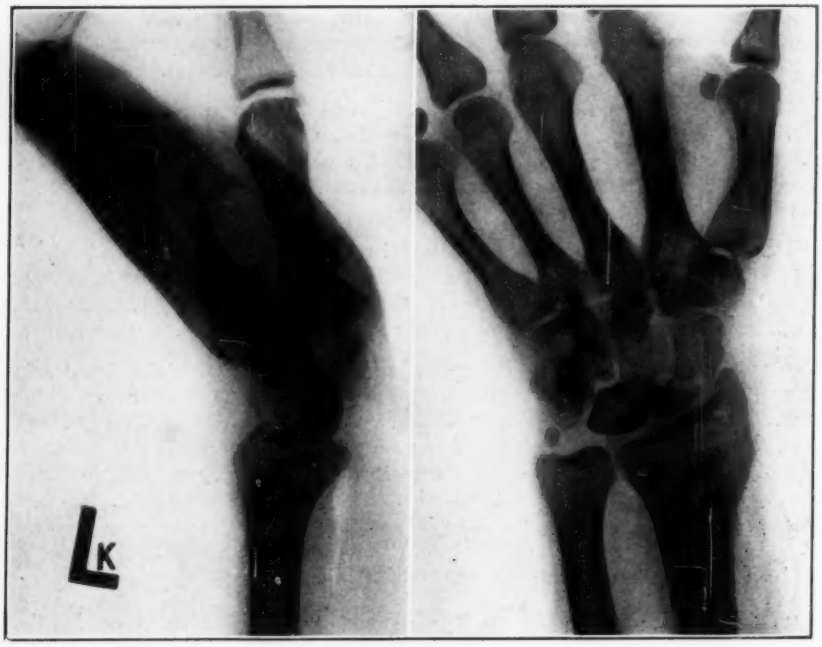

FIG. 10-B

Case 8. E. B. June 27, 1934. Following reduction.

2. The final result as shown by the roentgenogram varies between no union, a possible fibrous union, and bony union.

3. The end result should be evaluated by the clinical findings and not by the roentgenograms.

4. The results obtained both by the bone-graft and the bone-peg operations clearly prove that it is no longer necessary to remove the scaphoid.

5. The bone-peg operation, which is much easier to perform, leaves the anatomy undisturbed, the wrist strong and free from disability other than some limitation of dorsal flexion, and the patient satisfied.

REFERENCES

1. Adams, J. D., and Leonard, R. D.: Fracture of the Carpal Scaphoid. A New Method of Treatment with a Report of One Case. New England J. Med., CXCVIII, 401, 1928.
2. Berlin, David: Position in the Treatment of Fracture of the Carpal Scaphoid. New England J. Med., CCI, 574, 1929.
3. Burnett, J. H.: Fracture of the (Navicular) Carpal Scaphoid. New England J. Med., CCXI, 56, 1934.
4. Murray, Gordon: Bone Graft for Non-Union of the Carpal Scaphoid. Surg. Gynec. Obstet., LX, 540, 1935.

TRAUMATIC DISLOCATION OF THE ANKLE WITHOUT FRACTURE

A Case Report

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*From the Orthopaedic Division of the City Hospital *, New York City*

We wish to report the following case as illustrative of the production of a rare injury by means of an unusual mechanism.

L. K., white male, aged forty, was brought to the Hospital by ambulance on October 5, 1936, with a history that a half hour previously he had caught his right foot in a loop of heavy wire which became entangled in the rotating shaft of an electric motor. He was dragged toward the machine and his foot powerfully and markedly adducted and inverted. The machine was stopped when he was just about straddling the axle.

Upon examination, the foot was held immobile, displaced inward and backward. Point tenderness was present at the lower end of the right tibia. We assumed at that time that we were dealing with a fracture-dislocation of the ankle joint. Roentgenographic examination by Dr. George J. Plehn revealed a medial and posterior dislocation of the right foot. (See Figures 1 and 2.) There was no definite evidence of fracture. There must have been a tear of the lateral and anterior ligaments of the ankle joint. There were two small shadows along the medial aspect of the astragalus which could not definitely be identified (Fig. 1). These were later shown not to be fractures.

Putting traction on the heel and gradually dorsiflexing the foot easily reduced the dislocation. Reduction was maintained by plaster sugar-tong and posterior molded splints

FIG. 1

Anteroposterior view of dislocated ankle. Note the foot is in varus position (inversion).

FIG. 2

Lateral view of dislocated ankle. The astragalus and the foot are carried backward. The lower tibia and fibula are resting on the neck of the astragalus.

* Surgical Service of Lyman W. Crossman, M.D.

FIG. 3

Anteroposterior view, showing dislocation reduced.

FIG. 4

Lateral view, showing dislocation reduced.

from the tibial tubercle to the toes. Roentgenograms, taken the next day, revealed complete reduction of the dislocation. (See Figures 3 and 4.) At the end of ten days the plaster splints were discarded and an Unna boot was applied to the foot and leg, at which time the patient had a range of only 15 degrees of ankle motion. He was discharged from the Hospital and referred to the Orthopaedic Clinic.

We lost sight of him for the next five months. He next appeared at the Clinic on March 3, 1937 and gave a complicated history of having been elsewhere. He stated that he had worn a cast for five weeks and had then been given baths and passive ankle motion plus baking and massage. He stated that after a day's extensive walking he sometimes had slight ankle pain. There was a slight suggestion of a limp in his gait which we ascribed to habit at this stage. His range of ankle motion had increased considerably over the 15 degrees which he had on discharge from the Hospital. He now had active flexion-extension ankle motion from 95 to 135 degrees, which may be considered normal.

DISCUSSION

While fractured ankles are very common and dislocation results in about 20 per cent. of these cases [4, 9], it is very rare to find dislocation of the ankle uncomplicated by fracture, such a condition having been reported by only six authors in the last ten years.

Consensus of opinion [3, 7, 8] as to the mechanism of these dislocations is that they occur when the plantar-flexed foot meets a sudden obstruction, as in alighting. Plantar flexion with the body weight pushing the tibia downward and forward favors dislocation, because the astragalus fits more loosely in the mortise in this position. A fall on the plantar-flexed foot sometimes results in a backward displacement of the astragalus with the mortise sliding into the dorsum of the foot. Sometimes the astragalus is pinched from behind by the ground impact pushing up from below through the calcaneum. This pinching causes the astragalus to be

propelled forward out of the mortise much in the same fashion that a slippery melon seed is squeezed from between the fingers. Displacement inward or outward depends upon whether the foot is in the position of varus or valgus at the time of impact. This propulsive type of dislocation is frequently accompanied by rotation of the astragalus about its long axis. Sometimes [4, 9] the inferior articular surface of the astragalus rotates as much as 180 degrees and articulates with the mortise. Such injuries naturally interfere materially with the blood supply of the astragalus. Schmitt has reported necrosis of the astragalus following injury.

As in our case, reduction may often be easily accomplished by manipulation. On the other hand, Hirschfield, Pegreffi, and Schmitt found operative reduction the solution in their cases. Pin traction or operative reduction have been necessary in more complicated cases [3, 5, 8].

REFERENCES

1. Aboulker, P., et Herbert, J. J.: Luxation tibiotarsienne. Ann. d'Anat. Path., XII, 217, 1935.
2. Dehne, Ernst: Ein Fall von unvollständiger Luxation des Talus als Folge wiederholter Verletzungen im oberen Sprunggelenk. Zentralbl. f. Chir., LX, 688, 1933.
3. Hirschfield, I.: Isolierte unkomplizierte Talusluxation. Zentralbl. f. Chir., LIX, 2227, 1932.
4. Paal, Erwin: Endausgänge traumatischer Fussgelenkluxationen. Arch. f. Orthop. u. Unfall-Chir., XXIX, 369, 1931.
5. Pegreffi, Enrico: Di un caso di lussazione talo-crurale senza frattura. Riforma Med., L, 963, 1934.
6. Piersol, G. A.: Human Anatomy. Ed. 7, p. 450. Philadelphia, J. B. Lippincott Co., 1919.
7. Scharsich, K.: Isolierte unkomplizierte Talusluxation. Beitr. z. klin. Chir., CLI, 566, 1931.
8. Schmitt, W.: Zur operativen Behandlung der Talusluxation. Deutsche Ztschr. f. Chir., CXXX, 321, 1914.
9. Shands, A. R., Jr.: Fracture Dislocations of the Ankle. An Analysis of a Series of 109 Cases. Int. J. Med. and Surg., XLII, 238, 1929.

AN OPERATION FOR MENISCECTOMY OF THE KNEE

BY DAVID M. BOSWORTH, M.D., NEW YORK, N. Y.

Early in 1932 the author was forced to reoperate on three knees in close succession and in each case to remove the posterior third of the lacerated meniscus, incompletely removed at a previous operation. Because of this unfortunate circumstance, the writer immediately began using two separate incisions into the knee joint in all meniscus operations, so as to remove completely the torn cartilage and to obviate the danger inherent in leaving the posterior portion in the knee. In May 1934, while operating on a large cyst of the meniscus and following the cyst backward through an oblique anterior skin incision, it was found possible to retract the skin, with the knee flexed, and to enter the capsule behind the collateral ligament through a second capsule incision. Since that time, the single skin incision with a double capsule incision has been used and all menisci have been removed entirely and completely.

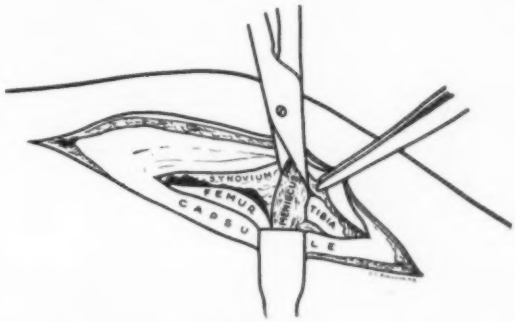

FIG. 1

Diagram of operative procedure, showing the anterior skin and capsule incision, the base of the meniscus being freed in front, and the blades of the scissors above and below the meniscus.

As will be seen from a consideration of the bibliography, opening the knee joint anteriorly and posteriorly at one operation is not a new procedure, but at the present time it is not commonly employed. The present report is for the purpose of emphasizing the necessity for complete removal of the meniscus, of showing the sim-

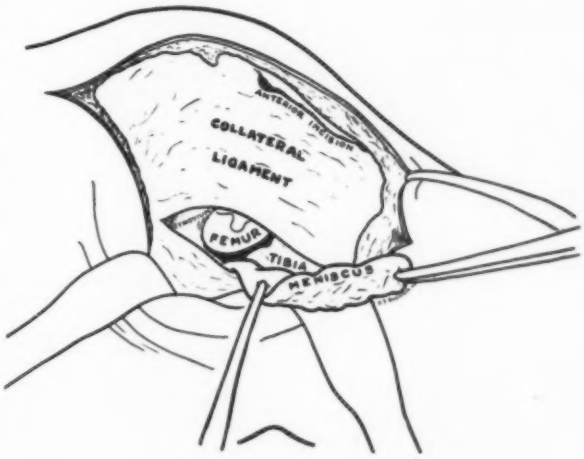

FIG. 2

Diagram of operative procedure, showing the knee flexed, the skin and subcutaneous tissue with the patellar branch of the saphenous nerve drawn backward, and the posterior capsule incision exposing the posterior compartment of the joint and the meniscus.

plicity of a double capsule incision with a single skin incision, and of corroborating previous reports as to the same uneventful convalescence as is secured with a single incision.

OPERATIVE TECHNIQUE

The first step of the operation consists of an oblique incision slanting upward and slightly backward over the anterolateral or anteromedial aspects of the joint, depending upon which meniscus is to be removed. Such an incision will avoid injury to the patellar branch of the saphenous nerve, since it parallels the course of this nerve. The skin and subcutaneous tissue can be drawn forward and the capsule opened at the usual point anteriorly, in line with its fibers, by a vertical incision. (See Figure 1.) The synovium above the meniscus should be opened between two pairs of forceps, care being taken not to mark or to cut the articular surface of the underlying femoral condyle. The small synovial pouch below the meniscus, between it and the tibia, should be opened in similar fashion. By means of curved scissors, one blade of which is placed above and the other below the meniscus, the anterior end of the meniscus can be freed from the synovium and the coronary ligament. In like manner, the base of the meniscus can be dissected free from its attachment to the collateral ligament. The knee is then flexed and the skin and subcutaneous tissue are dissected backward from the collateral ligament close to the capsule of the joint. The capsule is opened over the posterolateral margin of the femoral condyle behind the collateral ligament by a vertical incision in line with its fibers. The anterior portion of the meniscus is then passed backward under the collateral ligament, and its posterior third can be well visualized extending into the back of the joint. (See Figure 2.) The posterior third is freed from its attachment with scissors as far back as the posterior tibial spine. If a good view of the extreme posterior tip cannot be ob-

FIG. 3

Triple bucket-handle fracture of a meniscus which was removed intact through the incision described.

FIG. 4

Unusual fringed laceration of a meniscus which was removed intact.

FIG. 5

Laceration and cyst of a medial meniscus which was removed intact through the incision described.

tained, it can be divided by a tonsil snare, thus avoiding any danger of laceration of the posterior crucial ligament.

When the knee is straightened, the posterior incision will be found to close tightly. No sutures have been used on the posterior capsule incision in the past fifteen cases and no trouble has been experienced in this respect. The anterior incision is closed with interrupted fine silk sutures, care being taken to draw the subpatellar fat pad out of the joint by including a portion of it in the suture. The skin and subcutaneous tissue are closed with interrupted silk, and a dressing wrung out of Dakin's solution is applied with a pressure bandage. The pressure bandage is cut two hours later and the knee is rebandaged.

END RESULTS

The technique described has been used in twenty cases with no prolongation of convalescence and without causing joint relaxation or lack of mobility. Patients have been relieved of the necessity of a second external scar, and compensation schedules show losses lower than those in cases with two external scars. Three knees have been completely opened on both sides at the same operation by two skin incisions and four capsule incisions, so that in each case the knee joint could be explored. Convalescence in all three cases was the same as in cases where a single skin and capsule incision has been employed. Examples of unusual menisci removed intact by this procedure are shown in Figures 3, 4, and 5.

SUMMARY

The operative procedure which has been presented allows complete removal of a meniscus of the knee through a single skin incision and a double capsule incision, avoiding the possibility of injury to the patellar branch of the saphenous nerve and the presence of a second skin cicatrix. All lines of incision are in the direction of tissue structure and are so located as to avoid strain on knee motion.

REFERENCES

BRACKETT, E. G., AND OSGOOD, R. B.: The Popliteal Incision for the Removal of "Joint Mice" in the Posterior Capsule of the Knee-Joint. A Report of Cases. Boston Med. and Surg. J., CLXV, 975, 1911.

BRISTOW, W. R.: Internal Derangement of the Knee Joint. J. Bone and Joint Surg., XVII, 605, July 1935.

CAVE, E. F.: Combined Anterior-Posterior Approach to the Knee Joint. J. Bone and Joint Surg., XVII, 427, Apr. 1935.

HENDERSON, M. S.: Posterolateral Incision for the Removal of Loose Bodies from the Posterior Compartment of the Knee-Joint. Surg. Gynec. Obstet., XXXIII, 698, 1921.

KLEIN, ARMIN: Arthrotomy at the Knee—Posterior Incision. J. Bone and Joint Surg., XVI, 705, July 1934.

OSTEOGENIC SARCOMA OF THE ASTRAGALUS

Report of a Case

BY OTHO C. HUDSON, M.D., F.A.C.S., HEMPSTEAD, LONG ISLAND, NEW YORK

Osteogenic sarcoma is the most frequent malignant bone tumor. The long bones are most often attacked, while the small bones are relatively immune.

CASE REPORT

V. W. (patient of Dr. E. C. Braynard), white, male, twenty-two years of age, a student, was seen by the writer in September 1934.

In April 1934, the patient had had a gradual onset of pain in the dorsum of the right foot with swelling. The pain had become worse in May and weight-bearing was stopped.

Fig. 1

Roentgenogram of the right foot, taken on May 8, 1934, showing soft-tissue swelling.

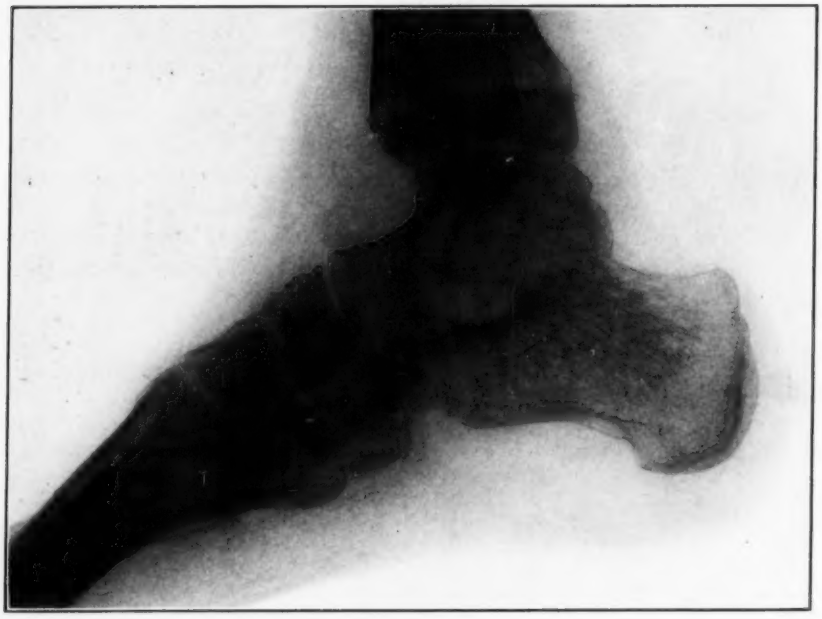

FIG. 2

Roentgenogram of the right foot, taken on August 17, 1934, revealing a tumor arising from the neck of the astragalus.

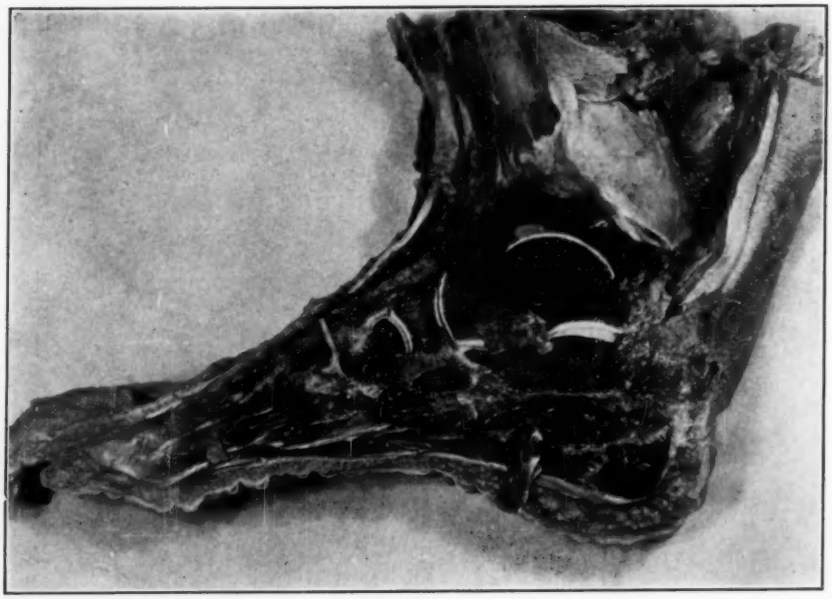

FIG. 3

Right foot after amputation, showing the tumor arising from the neck of the astragalus.

There was a constant ache in the foot, but it did not keep him awake at night. The pain had become steadily more severe.

Examination on September 7, 1934, revealed atrophy of the right thigh and calf. There was enlargement of the ankle and the foot with marked limitation of all motions in the ankle. The foot was held in the valgus position. There was marked induration of the periarticular structures about the ankle and the midtarsus. Marked tenderness was present over the astragalus. A small hard mass was felt over the dorsal surface of the astragalus.

A roentgenogram of the right foot, taken on May 8, 1934, revealed a soft-tissue swelling beneath the external malleolus. A later roentgenogram, taken on July 20, 1934, disclosed marked decalcification of all the tarsal bones. Considerable soft-tissue swelling was noted over the anterior portion of the ankle. There was an apparent area of erosion of the dorsal surface of the astragalus. A further roentgenogram, taken on August 17, 1934, showed increased decalcification of the bones. A tumor mass could be seen over the neck of the astragalus, with a definite destruction of the cortex beneath.

FIG. 4

The partly dissected foot, showing the tumor at the point of the hemostat.

Roentgenographic examination of the chest was negative. The Wassermann test and the urine were also negative. Blood count showed:

Red blood cells—4,600,000
Hemoglobin—90 per cent.
White blood cells—14,900
Polymorphonuclear neutrophiles—77 per cent.
Large lymphocytes —17 per cent.
Small lymphocytes — 6 per cent.

On September 11, 1934, under a double tourniquet, a dorsal incision was made over the ankle into a tumor which was found to be highly vascular, gray, and granular. On frozen section a diagnosis of osteogenic sarcoma was made. An amputation was then done at the level of the upper third of the thigh.

The pathological report by Dr. J. S. Grewal was as follows: "The tissue is firm, friable, granular, and reddish-gray in color. There is a medial dorsal incision over the ankle extending down and exposing a broken-down, brownish, friable tumor mass

continuous with the astragalus. The tumor measures about three by two centimeters in diameter on the surface. The soft tissue about the tendons in this region is oedematous.

"Microscopic examination of the section of the piece of tissue reveals a moderately cellular structure. The cells are polyhedral and are arranged in a most disorderly fashion. In places quite a little fibrillar substance is deposited around them. In still other places the cells are elongated and closely packed. Numerous anastomosing strands of calcified portions of the tissue are also present. Some of these areas are definitely ossified. Scattered throughout the tissue a number of multi-nuclear giant cells are present. Only occasional mitotic figures are seen. The blood vessels are also quite numerous, but their walls are thick and old."

The wound healed by first intention and on November 30, 1934, the patient was fitted with an artificial extremity. Roentgenographic examination of the chest on August 22, 1936, was negative. When last seen on April 22, 1937, the patient was in good condition with no complaints. He has been working continuously and regularly.

Tumors of the astragalus are very infrequently encountered. The Registry of Bone Sarcoma of the American College of Surgeons have three cases, including the one described which is registered as No. 1809. In all three cases the patients had the same initial symptoms, and there was a long interval from onset until the time of diagnosis. The roentgenographic interpretation and the histological findings were almost identical. From the histology, a better prognosis for life was given in each case than is usual in the same tumor of the long bones.

It would seem, from these few cases, that a five-year cure might be obtained in an osteogenic sarcoma of the astragalus.

REPAIR OF LACERATION OF FLEXOR POLLICIS LONGUS TENDON *

BY FRANK G. MURPHY, B.SC., M.D., F.A.C.S., CHICAGO, ILLINOIS

From the Department of Orthopaedic Surgery, University of Illinois College of Medicine

Laceration of the flexor pollicis longus tendon occurs so frequently, and function of the hand is so irreparably damaged by omission of its repair or by injuries to other muscles during the surgical repair, that it deserves special consideration. More difficulty is encountered in approximation of the severed ends than in any other tendon of the hand. H. P. Maloney states that the injury is usually caused by a stab wound from glass or porcelain handles on faucets. The patient when turning a faucet that is slightly stiff uses more exertion than ordinary and presses against the glass handle, sometimes with a considerable portion of his weight. The glass handle breaks obliquely and the point stabs directly into the palm, frequently into the thenar eminence of the hand. Several deeper structures are usually injured, but the one that is most frequently damaged and that is the most important is the flexor pollicis longus tendon.

The tendon lies deep in the hand, gliding over the first proximal phalanx and over the first metacarpal bone. It lies inside the outer head of the flexor pollicis brevis and to the inner aspect of the abductor pollicis and the opponens pollicis muscles. The last three muscles are supplied by branches from the median nerve. The tendon lies outside the adductor pollicis and the inner head of the flexor pollicis brevis, which are supplied by the ulnar nerve. It then courses upward under the annular ligament in its own compartment. In the wrist, the tendon lies under the median nerve, deep in the groove between the flexor carpi radialis and the palmaris longus tendons. It blends into its muscle from one and one-fourth to two inches above the annular ligament. Throughout its course, it has its own tendon sheath and its own mesotendon posteriorly.

A study of the pathogenesis explains several complicating features. When this tendon is severed in the palm, the proximal end retracts for a considerable distance and goes well up under the annular ligament. The reason for the extensive retraction of this tendon is its complete separation from other tendons which might exert some restraint in its course. No other single tendon in the palm retracts to such a great extent.

The diagnosis of this condition is made on the history of a recent injury, the presence of a wide or small deep laceration in the palm, and the loss of voluntary flexion of the distal phalanx of the thumb. Examination of the wound may reveal the distal end of the tendon in the

* Presented before the Chicago Orthopaedic Society, January 1935.

wound if the distal phalanx is passively sharply flexed, but the proximal end cannot be found in the wound regardless of flexion of the wrist, elbow, or hand.

The usual procedure in these cases is to dissect from the wound upward. In the effort to secure the proximal end of the tendon, rather extensive dissection is necessary and causes considerably more injury to the muscles of the thenar group. The greatest danger lies in the possibility of trauma to the branch of the median nerve to the thenar group. Eventually dissection has to be carried up under the annular ligament, which is cut to expose the tendon. After the tendon ends have been sutured and an attempt has been made to approximate all the structures cut or disturbed in the dissection, there frequently results more trauma than was imposed by the suturing of the original severed tendon.

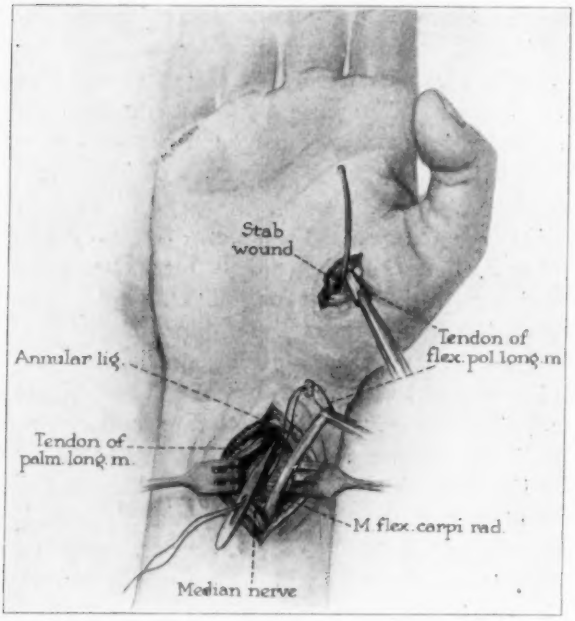

FIG. 1

The author's technique for repair of laceration of the flexor pollicis longus tendon.

The procedure proposed by the writer simplifies considerably the repair of this laceration.

The wound is cleaned with soap and water, as advised by Sumner L. Koch, and then examined. The operation is performed under local anaesthesia. The distal end of the tendon is found usually without extensive dissection. To obtain the proximal end of the tendon, an incision through the skin may be carried up from the wound to above the wrist, but a better procedure is to make a small new incision just above the annular ligament (Fig. 1). Through this new incision, dissection is carried down between the flexor carpi radialis and the palmaris longus tendons to the outer side of the median nerve. Here will be found rather deeply the flexor pollicis longus tendon, and, with a blunt dissector or probe, it may be lifted up without difficulty. Care must be observed here to cause as little damage to the mesotendon as possible. A silk ligature is passed through the end of the tendon, around it, and out through the end, so as not to constrict it. Then a curved blunt probe, with a slot at one end, is passed downward in the compartment which

was occupied by the flexor pollicis longus tendon. This space is very easily found. The silk strands are threaded into the slot in the rear end of the probe and tied. The probe is then passed on through the compartment, drawing the tendon after it and down through the original wound, where it is sutured to its distal severed end. The other structures are approximated, and the wound is closed without drainage.

Postoperatively, the thumb and forearm are immobilized with the thumb in marked flexion, so as to relax most of the traction on the sutured ends of the tendon. Flexion is maintained for three weeks. Then, gradually increasing passive and active movements are permitted. Physiotherapeutic measures may be used to facilitate earlier return of function to the stiffened hand muscles.

CASE REPORT

G. C., a barber, fifty-four years of age, came to the office on October 21, 1934, with a lacerated stab wound on the thenar eminence of the right palm and inability to flex the distal phalanx of the right thumb. On October 20, while turning a faucet, he had pressed rather forcefully on the procelain handle. The handle broke in an oblique direction, and the sharply pointed portion cut deeply into his palm before he could release pressure. Immediately there was rather profuse hemorrhage, which was controlled by pressure. He visited his family physician, who diagnosed a laceration of the tendons and advised operation. The next day he was referred to the writer.

On examination there was an open lacerated wound over the thenar eminence rather near the center of the palm. No infection was present. There was voluntary but painful flexion of the proximal phalanx of the right thumb. Voluntary flexion of the distal phalanx of the thumb was lost. The diagnosis was traumatic laceration and severance of the flexor pollicis longus tendon. The operation described was performed, using 1-per-cent. novocain anaesthesia.

On the twenty-ninth postoperative day, movement with gentle force was allowed and gradually increased. Heat was applied, and the hand was massaged daily. Movement and function were fully restored nine weeks after the accident, when he returned to work.

SUMMARY

1. Trauma to palmar structures from broken faucet handles is a frequent injury.

2. Retraction of the proximal severed end of the flexor pollicis longus tendon occurs to well above the annular ligament.

3. Much tedious dissection is eliminated, and the repair of the tendon is simplified by passing the proximal end under the annular ligament through a new incision.

REFERENCES

CALLANDER, C. L.: Surgical Anatomy. p. 885. Philadelphia, W. B. Saunders Co., 1933.

KOCH, S. L.: Injuries of Nerves and Tendons of Hand. Wisconsin Med. J., XXXIII, 655, 1934.

MALONEY, H. P.: Porcelain Faucet Handle Injuries. J. Am. Med. Assn., CIII, 1618, 1934.

FRACTURES OF THE PROXIMAL PHALANX OF THE THUMB

Flexion Treatment

BY S. A. JAHSS, M.D., NEW YORK, N. Y.

In a previous communication,[1] alignment and immobilization of fractures of the proximal phalanges were considered in detail. Those of the thumb were not included, since none were encountered at the time. Whether the author's flexion method would be practical in such cases could only be surmised. Recently such a fracture came under observation.

The history of the case and the physical findings are irrelevant. The roentgenograms (Fig. 1) showed a fracture of the proximal phalanx of the thumb, just distal to the midshaft. Dorsal angulation of the distal fragment was almost 90 degrees. Medial angulation of 15 degrees was also present.

Under general anaesthesia, the partial union in this three-weeks-old fracture was broken up. The proximal fragment was fixed by the thumb and index finger of one hand, and with the same fingers of the other hand the distal fragment was flexed into alignment. When it was thought that reduction was almost accomplished, the proximal fragment was released and the flexion on the distal fragment was con-

Fig. 1

Fracture of the proximal phalanx of the thumb, showing marked dorsal and mild medial angulation of the fragments.

tinued until the dorsal ligament of the metacarpophalangeal joint was tense. By adducting the thumb the medial aspect of this digit rested against the palm of the hand.

Immobilization in this position was accomplished by means of adhesive plaster strips (Fig. 2).

Roentgenograms taken after reduction (Fig. 3) showed a perfect alignment of the fragments.

FIG. 2

Immobilization with adhesive plaster strips.

FIG. 3

Perfect alignment of the fragments after reduction and immobilization by the author's method.

1. JAHSS, S. A.: Fractures of the Proximal Phalanges. Alignment and Immobilization. J. Bone and Joint Surg., XVIII, 726, July 1936.

TRAUMATIC DISLOCATION OF HEAD OF FEMUR IN A CHILD

BY CHARLES HAINES, M.D., NEW YORK, N. Y.

Traumatic dislocation of the head of a normal femur out of a normal acetabulum is probably very uncommon among children, for such a lesion is not even mentioned in text-books on fractures and dislocations. Therefore, the writer feels that the following case should be reported.

CASE REPORT

C. P., a white boy, six years of age, fell off a sled while coasting and caught the left foot against a wall in such a manner that the left femur was forcibly abducted beyond a right angle. He immediately felt severe pain in the hip and was unable to walk.

He was seen by the author within an hour after the accident. On examination, the greater trochanter of the left femur was found to be cephalad to the acetabulum. The left lower extremity measured about five centimeters less than the right. It was adducted, internally rotated, and partially flexed at the hip and knee,—the typical position of a dislocated hip.

Roentgenographic examination (Fig. 1) showed complete anterior dislocation of the head of the left femur, but there was normal configuration of the acetabulum and of the head of the femur. There was no fracture.

FIG. 1

Anterior dislocation of the head of the left femur.

The dislocation of the head of the femur was reduced by the Simpson method without an anaesthetic. (See Figure 2.) The ankles were held together by a bandage, and the child was put to bed and kept there for approximately five weeks. Convalescence was uneventful.

When last seen, four months after the accident, the child was able to play normally. There was no pain or discomfort in the hip, and all motions of the hip joint were normal. He seemed to have recovered fully from the results of the accident.

FIG. 2
After reduction.

SUMMARY

In this unusual case of a complete traumatic dislocation of the head of a normal femur from a normal acetabulum in a boy only six years of age, following treatment by the author, the hip had returned to normal four months after the accident.

A LIGHT HYPEREXTENSION BACK BRACE

BY EUGENE L. JEWETT, M.D., ORLANDO, FLORIDA

We are constantly searching for lighter and stronger mechanical means for immobilizing the various parts of the body. Nowhere is this more important than in the case of a fractured vertebral body, where the ambulatory patient must wear the correction cast or brace for many months.

Recently a patient of the author's, seventy-six years old, sustained a compression fracture of the twelfth thoracic vertebral body. She was of the very active energetic type, who would not consent to recumbency on a Bradford frame for long. She was put in a hyperextension bivalved plaster jacket with holes cut out here and there, so as to make it as light as possible. It weighed only approximately four pounds, but in a few days the patient declared that it was unbearable, even though the shoulder straps had been well padded to help distribute the load. She insisted that a brace be obtained for her within a few days, which precluded sending away for any aluminum or celluloid jacket. Having seen the three-point hyperextension back brace, described by Griswold in the July 1936 issue of *The Journal of Bone and Joint Surgery* (*XVIII, 784*), the writer decided to have a similar affair made.

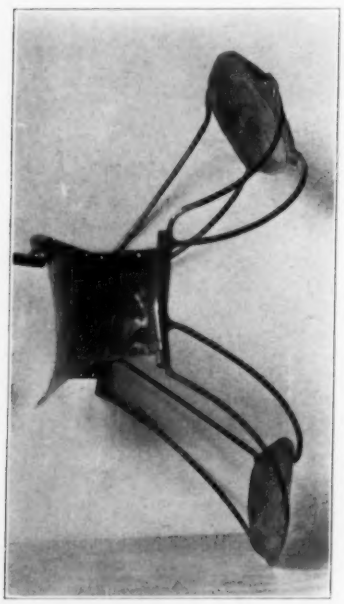

FIG. 1

Lateral view of steel hyperextension brace.

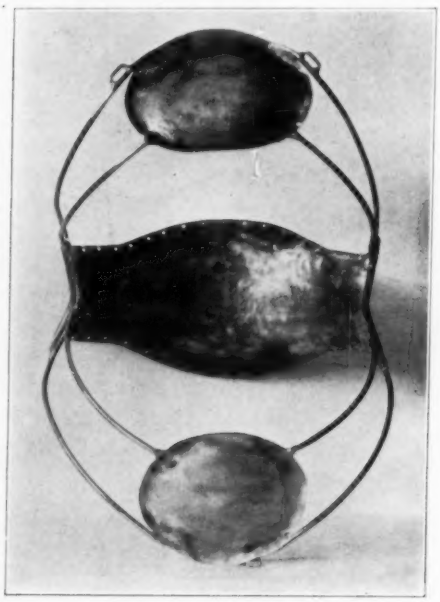

FIG. 2

Posterior view of steel hyperextension brace.

Another plaster-of-Paris jacket was made and in a day and one-half a local welding concern constructed the hinged brace from it. A lead steel was used, which was malleable and could be hammered and bent without too much trouble. It still had enough rigidity to keep the body in the hyperextended position. A minimum of felt and leather was applied, so as to reduce the weight as far as possible. The brace weighs only one and three-quarters pounds without the felt and leather covering and two and one-half pounds when complete. On the back of the brace additional felt strips were placed up and down about one inch apart, so as to take the pressure off the spinous processes. The two parts of the brace were held together by a fixed hinge on one side and a cotter pin lock on the other, which can be easily released. Places were made for shoulder straps, but the patient did not wear them. The author does not see the need for any adjustable parts to the brace by which the hyperextension can be changed. If it is made from a correctly applied plaster-of-Paris jacket, there is no necessity to alter the hyperextension in any way. Of course, Dr. Griswold's brace can be used without having any plaster-of-Paris cast made, and in that respect it is much more adaptable. However, it is the writer's opinion that in most cases it is better to make a brace from a plaster jacket, in order to be sure that all parts fit absolutely correctly.

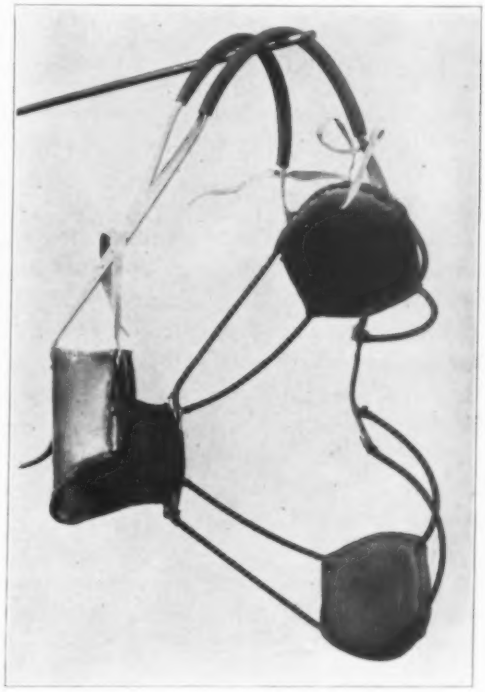

FIG. 3
Lateral view, showing brace opened.

The brace is taken off every night after the patient is recumbent on the Bradford frame. At first, the writer was doubtful about the advisability of changing so often from the brace to the Bradford frame, but close clinical observation and repeated roentgenograms show a maintenance of hyperextension and freedom from pain.

This patient weighs only about 115 pounds, and, of course, for a heavier person a proportionately stronger brace would have to be built. However, even for a heavy, obese person, the author believes this type of brace would be just as efficient and far more comfortable than the usual hyperextension immobilizing appliances. Of course, the celluloid jacket and the aluminum brace are very light, but they do not permit the same free use of the thoracic and abdominal muscles.

TREATMENT OF FRACTURES OF THE PELVIS

BY HARRY KOSTER, M.D., AND LOUIS P. KASMAN, M.D.,
BROOKLYN, NEW YORK

From the Koster Clinic, Crown Heights Hospital, Brooklyn

The method of treatment employed in fractures of the pelvis depends upon the location and extent of the injuries and the amount and direction of displacement of the fragments. It has long been known that fractures of the iliac fossae without displacement of the fragments after rest in bed for two or three weeks will heal to such an extent that the patient may then become ambulatory. Even in cases with displacement of the iliac fragments healing will also take place readily with or without immobilization by a pelvic sling or circular bandage or cast. Where the fractures involve the pelvic girdle, however, marked displacements must be corrected or serious consequences may result. There are various well-known methods by means of which such displacements may be corrected. In many cases, because the displacement of the outer fragment is in an inward direction, it has been stated that circular compression by sling, bandage, or cast is contra-indicated because it would tend to increase the deformity.

Our experience indicates that all patients who have fractures of any part of the pelvis, including the iliac portions, should also have the support of a pelvic sling, no matter what else is done for them. This support should be given immediately upon admission to the hospital and should be maintained constantly thereafter until healing has progressed to the point where mechanical aids to immobilize the fragments are no longer necessary. If after roentgenographic examination it is found that there are displacements which need correction by traction, the latter may then be applied without interference from the sling.

After an injury sufficiently severe to cause a fracture of the pelvis, the patient suffers considerable pain from the trauma. The sharp edge of this pain would quickly wear off and leave the patient relatively comfortable were it not for the fact that to it are added recurrent traumata resulting from movement of the fragments. These fragments have attached to them on one side the muscles of the abdominal wall and the iliopsoas, and on the other side the gluteus maximus, the small muscles between the girdle and the femur, and the muscles which adduct the latter. Thus, any movement of the body or lower extremity is bound to produce pain by moving the fragments, unless they are supported. Traction on the lower extremity alone does not sufficiently immobilize the fragments to prevent this pain.

The sling, however, insures freedom from this pain by supplying the necessary immobilization. We have devised an apparatus, shown in Figure 1, by which it is possible to maintain constant pressure upon the

fragments and yet allow the patient sufficient freedom of movement for the prevention of bedsores and hypostatic congestion, for easy bowel evacuations, and for the proper hygienic care.

This apparatus consists of a baseboard, four feet long and six inches wide, on which, six inches from each end, are erected two uprights, two and one-half feet long and six inches wide. In a cut-out at each end of the baseboard and of each upright a pulley is fitted. The baseboard is placed under the mattress at the site upon which the buttocks of the patient will rest. The patient is then placed in the dorsal recumbent position on a sling laid on the mattress at that site, to the ends of which are connected cords which cross the median line to the opposite upright pul-

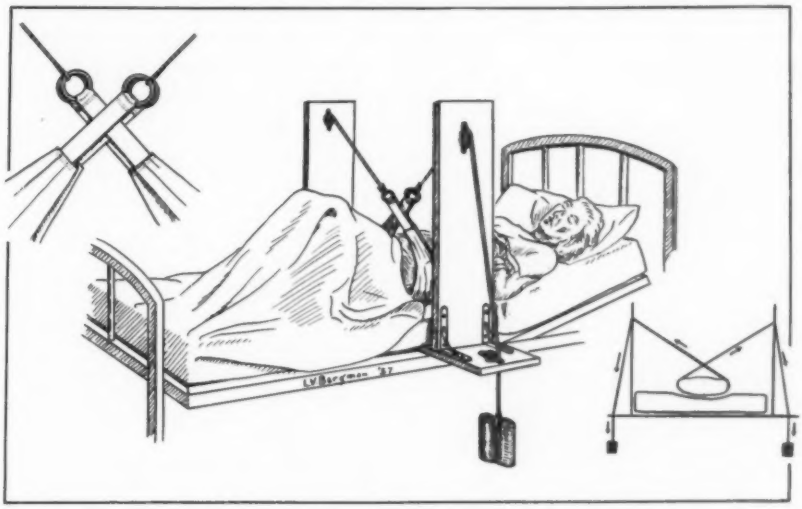

FIG. 1

leys over which they hang. They are prevented from resting against the sides of the bed by the pulleys in the baseboard and they are maintained taut by ten-pound weights swinging freely on the ends.

If the patient's buttocks are raised, the weights sink nearer the floor, but the pull on the sling is not changed. Thus, the patient's hips and body can move or be moved laterally and up off the bed without diminishing the compression of the sling on the pelvis.

In our last fourteen cases, all treated by this method, the freedom from pain of motion has been a striking feature in the clinical course of the fractures. As a result, we feel that the use of the sling should constitute a part of the treatment of all fractures of the pelvis.

A HARNESS FOR USE IN THE TREATMENT OF ACROMIOCLAVICULAR SEPARATION

BY ALLAN H. WARNER, M.D., WOODSIDE, NEW YORK

It has been observed that there is no wholly satisfactory artificial device available for the treatment of acromioclavicular separation. In many cases of this condition, the separation is very slight, and satisfactory repair might be accomplished if the separation were reduced and the parts held in proper apposition. The harness described herein does maintain the shoulder bones in proper relation, and is, therefore, to be considered an important aid in the medical treatment of acromioclavicular separation. It has the added virtue of permitting a high degree of motion at the elbow joint while completely restricting motion at the shoulder.

The apparatus consists of numerous canvas straps, buckles, pads, and a leather pocket. (See Figures 1 and 2.) The present description and illustrations apply to a support for the left shoulder. It is possible to make the apparatus reversible for left or right, and adjustable for variations in stature.

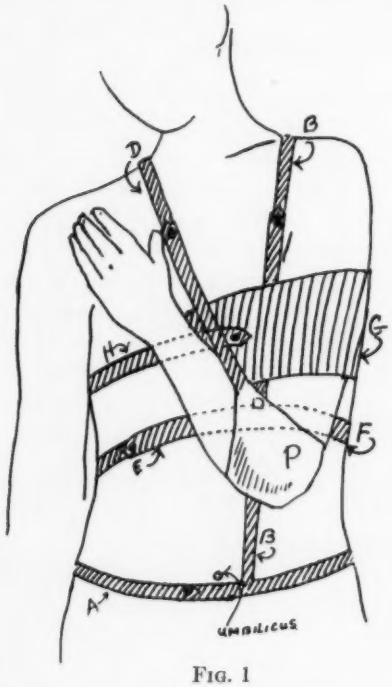

FIG. 1

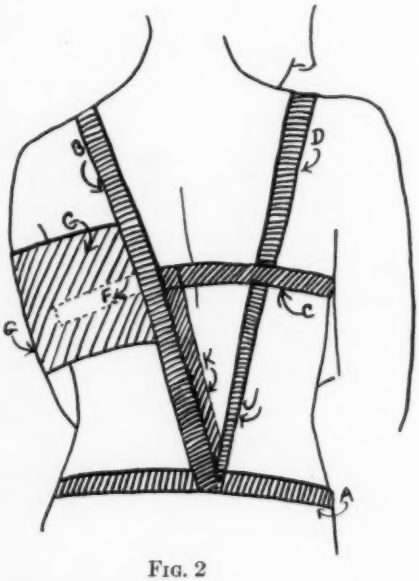

FIG. 2

The pocket, *P*, through straps *D* and *B*, pulls the arm upward. The attachment of *B* to the circular straps *EF* and *A* prevents the elbow pocket from sliding toward the midline.

The broad strap *G* pushes the arm onto the anterior surface of the body and holds it there.

Strap *B* depresses the clavicle.

The other straps serve to strengthen the apparatus, and to maintain the key straps in position.

The tip of the acromion and the external extremity of the clavicle have thus been brought into close approximation with one another. This has been accomplished as follows:

1. There is an upward pull on the flexed forearm and elbow, the humerus being held more or less parallel to the vertical axis of the body. The upward pull is thereby transmitted to the shoulder and to the acromion.

2. The arm, always parallel to the vertical axis of the body, is rolled forward as far as it will go, which will bring it to about the anterior axillary line. This carries the acromion medially closer to the clavicle.

3. The clavicle is pressed downward, bringing its outer extremity closer to the acromion.

The patient on whom the device was originally used was employed as a machine feeder. While wearing the harness, he was able to continue to do the work which required a rather sweeping circular motion with the affected limb. Numerous other devices had been tried on this patient. All adhesive tape and bandage combinations had to be discarded because they were too irritating to his skin. Our device he kept in place day and night, with only brief intervals to permit bathing. Eight weeks after the initial trauma, the patient was permitted to discard the girdle completely because it was found that a perfect anatomical result had been obtained. There was some beginning atrophy of the neighboring muscles and limitation of abduction of the humerus to about 75 degrees. These defects are being treated.

PORTABLE EXTREMITY TRACTION FOR CHILDREN * †

BY HENRY MILCH, M.D., F.A.C.S., NEW YORK, N. Y.

Associate Attending Orthopaedic Surgeon, Hospital for Joint Diseases

The application and maintenance of efficient traction in children frequently presents such difficulties as to necessitate hospital care. During a recent quarantine of our pediatric wards, this problem arose at a time when hospitalization was impossible. To continue with the necessary treatment, we were forced to adopt the principle of the banjo splint. Considering the trunk as the hand, and the extremities as the fingers, to which traction was to be applied, we devised a trunk banjo splint and a modified splint, which gave complete satisfaction.

In two cases in which this method was used, a slightly different application of the fundamental principle was made in each case. The first was a case of pneumococcal synovitis of the hip, in which the typical banjo splint was used. The second was a case of fracture of the shaft of the right femur, in which overhead traction was accomplished by means of a slight modification.

The apparatus is extremely simple to apply and consists of a plaster-of-Paris trunk piece in which an iron bar for traction is incorporated. The chest, shoulders, and iliac

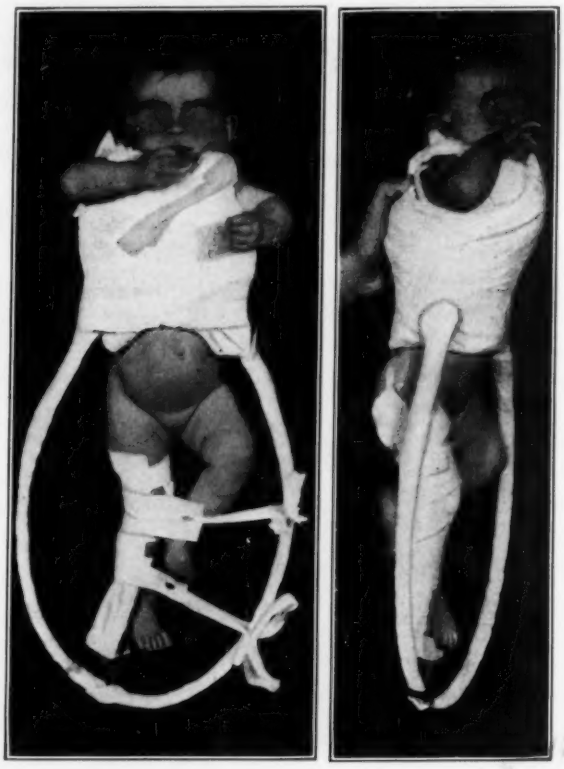

FIG. 1-A FIG. 1-B

Fig. 1-A: Shows the banjo type of splint, the body plaster, and the incorporated iron rod, with the traction strips and the rotation tabs.

Fig. 1-B: Lateral view of the banjo splint applied in a case of pneumococcal infection of the hip joint.

* From the Service of Harry Finkelstein, M.D.

† Presented before the Orthopaedic Conference at the Hospital for Joint Diseases on April 20, 1937.

FIG. 2-A

FIG. 2-B

The modified traction splint for fracture of the femur.

crests are meticulously protected against the likelihood of pressure sores by the careful insertion of felt padding. A typical plaster-of-Paris bandage, with shoulder straps, is applied to the trunk and is carefully molded around the iliac crests. When the plaster has properly set, a sufficiently large piece of half round, cold rolled iron, one-eighth by one-half of an inch, is bent into appropriate shape (Figs. 1-A, 1-B, 2-A, and 2-B) and is covered with a plaster-of-Paris bandage. Adhesive stickers are applied to the extremity, and a wooden spreader is inserted. Elastic traction, either by rubber bands or by rubber tubing, is then applied. By means of adhesive tabs applied to the stickers and carried across to the opposite side, internal or external rotation may be accomplished.

FIG. 3

Roentgenogram showing the reduction obtained by means of the traction splint.

The principle of combining body and leg traction in a portable splint is not new. Cabot's posterior wire splint, especially as modified by Flint to allow traction, affords an excellent example of this method of treatment. However, it is felt that the use of a plaster bandage which encircles the

trunk is apt to give more stability to the traction than can be obtained by simple adhesive bandaging.

The method may be adapted to provide traction to the lower as well as to the upper extremities. In fracture of both femora, the iron banjo splint, instead of the bayonet-shaped splint, may be used. The apparatus allows correction of adduction, abduction, flexion, or extension deformities. It permits easy nursing and surgical approach to the whole of the lower extremity. Because of the fact that the plaster does not extend below the iliac crests, soiling seldom occurs. The necessity for prolonged or costly hospitalization is minimized.

A PORTABLE FRAME FOR THE SUSPENSION OF FRACTURES OF THE FEMUR IN CHILDREN *

BY GEORGE W. HAWLEY, M.D., F.A.C.S., BRIDGEPORT, CONNECTICUT

From the Orthopaedic and Fracture Service of the Bridgeport Hospital

The device shown in Figures 1, 2, and 3, designed by the author, has been in use at the Bridgeport Hospital for several years and has proved very satisfactory. It makes the patient portable and the stay in the hospital short. This is of benefit to the child, the parents, and the hospital. Children are anxious to go home and parents are glad to take them home. At the same time the hospital benefits by renting the apparatus which soon pays for itself.

FIG. 1

Showing patient with a fracture of the shaft of the femur in the frame, with the leg in overhead suspension. The pelvis is raised for gravity traction. The leg is exposed for roentgenographic examination. The patient and the frame are one unit and are portable.

The construction of this frame is simple. It can be made in the workshop of a general hospital. The frame has a spring bottom like a child's crib. The height of the overhead bar can be adjusted to the length of the leg. Traction can be increased by raising the bar, or by shortening the traction straps.

FIG. 2

Patient on his way home.

FIG. 3

Patient on lawn at home a few days after leaving the hospital, having "fun with a fracture".

* The patient in the fracture frame was shown at the Clinical Session of the Meeting of the Connecticut State Medical Society held in Bridgeport, May 19 and 20, 1937.

AVULSION FRACTURE OF THE ISCHIAL TUBEROSITY

BY HAROLD H. COHEN, M.D., NEW YORK, N. Y.

*From the Hospital for Joint Diseases *, New York City*

A careful search of the literature has revealed only three cases of avulsion fracture of the ischial tuberosity.

The first case was reported by an Englishman, J. M. Berry, in 1912. The patient, twenty-three years old, sustained the injury while running and, because of persistent pain and disability three years afterward, the displaced tuberosity was removed.

The next case was recorded in the United States by Milch in 1926. This patient was a girl, eleven years old, who, while attempting to regain the upright position from the sitting "split" position, experienced a sudden sharp pain in the right buttock and fell back. In this case, not only was the ischial tuberosity avulsed, but the entire right side of the pelvis was displaced downward. Here, apparently, the sheering stress was such as to tear the ligaments binding the symphysis pubis and the sacro-iliac joint.

The most recent case was reported in Germany in 1933 by Hellmer. His patient was seventeen years old and an athlete. The injury occurred while running 400 meters. Open operation was immediately performed, and the avulsed tuberosity was replaced and held in position by several chromic catgut sutures passed through the obturator foramen. Bony union was noted at the end of four months, and the patient was allowed to compete in athletics one month later.

Because of the rarity of this fracture, the author wishes to place on record the following case.

A colored boy, sixteen years old, was first seen in the Out-Patient Department of the Hospital for Joint Diseases in November 1936. He complained of pain in the left buttock and inability to take long steps with the left leg. The history was as follows: While playing football, he had caught the left foot in a hole in the ground, had crossed the right foot over the left, and, in attempting to swing the left leg forward, had experienced a sudden sharp pain in the left buttock. He had fallen to the ground and had been brought home, where he had remained in bed for one week. He then decided to come to the Hospital.

Examination revealed a well-developed, rather tall, colored boy who did not appear to be in any pain, but who walked with a definite left limp. There was a reduced left stride. When sitting on a hard chair, he complained of pain in the left buttock. When an attempt was made to passively extend the flexed knee while the patient was seated, he complained of pain in the left buttock. Left straight-leg raising was present to 145 degrees. No tenderness could be elicited over the ischial tuberosity, and rectal examination was negative for any mass or tenderness. Measurements of both extremities for real or apparent shortening did not disclose anything significant.

Roentgenographic examination of the pelvis was ordered, and the following report

* Service of Leo Mayer, M.D.

was returned: "Examination of the pelvis and of the left hip joint discloses a soft-tissue calcification about the size of a pecan situated near the left ischial bone. The contours of the ischium show irregular erosion. In view of the history of trauma, the soft-tissue shadow represents an avulsed ischial epiphysis." (See Figure 1.)

The patient was kept at rest for three weeks and discharged for follow-up care in the Out-Patient Department. He was next seen on December 5, 1936, and the following note was made: "Patient states that he has played football and feels very well. Examination reveals that there is still some weakness of the flexors of the left knee." The patient was again seen on March 15, 1937, and examination at this time revealed a complete return of hamstring power. A follow-up roentgenogram (Fig. 2) was taken on May 7, 1937, and the report was as follows: "Examination of the pelvis reveals the previously described avulsion fracture of the ischial tuberosity. There is beginning bony union."

FIG. 1

November 10, 1936, roentgenogram showing avulsion of the ischial epiphysis.

FIG. 2

May 7, 1937, roentgenogram showing beginning bony union.

In the differential diagnosis the only possible source of error is confusion with an ossifying hematoma. The location of the lesion, its crescentic appearance, the erosion of the ischium, the manner of production, and its occurrence in an individual of the epiphyseal age should make the diagnosis certain. In summation, the following points are to be noted:

1. Avulsion fracture of the ischial tuberosity, though uncommon, should always be suspected up to the age of twenty-five when union generally occurs.

2. Bony union is not necessary for a resumption of normal activities.

3. This fracture occurs in one of two ways, or in a combination of both,—a sudden forceful pull on the ischial tuberosity while the pelvis is fixed in flexion, or a sudden flexion of the pelvis with the lower extremity fixed and the knee in complete extension.

4. The treatment of choice is conservative,—namely, complete rest in bed with the knee in flexion if much hamstring spasm exists.

REFERENCES

BERRY, J. M.: Fracture of the Tuberosity of the Ischium Due to Muscular Action. J. Am. Med. Assn., LIX, 1450, 1912.

HELLMER, H.: Ein Fall von traumatischer Ablösung der Epiphyse des Os ischii. Arch. f. orthop. u. Unfall-Chir., XXXIV, 45, 1933.

MILCH, HENRY: Avulsion Fracture of the Tuberosity of the Ischium. J. Bone and Joint Surg., VIII, 832, Oct. 1926.

News Notes

The Congress of the **Jugoslavian and Czechoslovakian Orthopaedic Societies** will be held in Belgrade on October 17 and 18. The principal topic for discussion will be Congenital Dislocation of the Hip. The conservative treatment will be presented by Dr. D. Yovtchitch who is President of the Congress, and operative treatment will be discussed by Prof. Zahradníček, of Prague, President of the Czechoslovakian Society.

The Fifteenth Annual Meeting of the **Academy of Physical Medicine** will be held at the Hotel Walton, Philadelphia, October 19, 20, and 21. Further information may be obtained from the Chairman of the Program Committee, Dr. William D. McFee, 41 Bay State Road, Boston, Massachusetts.

The Pan American Medical Association has announced its Seventh Cruise Congress to Havana and the West Indies. The S.S. "Queen of Bermuda", chartered for the Cruise, will sail from New York January 15, 1938. Applications should be sent to the Pan American Medical Association, 745 Fifth Avenue, New York, N. Y.

The Second Congress of the **Brazilian Association of Orthopaedic Surgery and Traumatology** was held in Rio de Janeiro, Brazil, July 1–4, under the direction of Dr. Achilles Araujo, President. Dr. Fred H. Albee of New York, Honorary President, was the guest speaker. An interesting program was presented and the Congress was well attended.

The annual meeting of the **Advisory Board for Medical Specialties,** which is the coordinating Board of the twelve certifying boards in the various specialties, the Association of Medical Colleges, the American Hospital Association, the Federation of State Medical Boards of the United States, and the National Board of Medical Examiners, was held at Atlantic City, New Jersey, on June 6, 1937.

The following officers were elected:

President: Willard C. Rappleye, M.D., New York, N. Y.
Vice-President: W. P. Wherry, M.D., Omaha, Nebraska
Secretary-Treasurer: Paul Titus, M.D., Pittsburgh, Pennsylvania
Executive Committee: The Officers and
W. B. Lancaster, M.D., Boston, Massachusetts
R. C. Buerki, M.D., Madison, Wisconsin

Dr. Louis B. Wilson of Rochester, Minnesota, the retiring President of the Board, was elected an emeritus member of the Board.

The American Academy of Orthopaedic Surgeons will hold its Sixth Annual Convention in Los Angeles, California, January 15–19, inclusive. The headquarters will be at the Biltmore Hotel situated in the downtown district of Los Angeles.

The Program Committee have assembled an interesting and diversified group of papers. There will be a symposium on the subject of non-union and bone-graft surgery. There will also be a symposium on fractures of the spine. The tentative program includes a wealth of interesting material presented by the ablest orthopaedic surgeons of America.

The local committee have made arrangements for the entertainment which will prove to be of interest to all. The annual golf tournament will be held; there will be visits to the motion picture studios and other features of interest about Los Angeles.

The Association of Military Surgeons will hold its convention at the Ambassador Hotel, Los Angeles, California, October 14–16.

The Twenty-Seventh Annual Clinical Congress of the **American College of Surgeons** will be held in Chicago from October 25 to 29. The headquarters will be at the Stevens Hotel. A committee of Chicago surgeons headed by Dr. Vernon C. David, Chairman, and Dr. Michael L. Mason, Secretary, is in charge of local arrangements. Further information may be obtained from Mr. A. D. Ballou, General Manager of the Congress, 40 East Erie Street, Chicago, Illinois.

BRITISH ORTHOPAEDIC ASSOCIATION

The British Orthopaedic Association, under the Presidency of Mr. W. R. Bristow, held its Spring Meeting from May 17 to 21 in Copenhagen and Stockholm. The party consisted of some sixty members and their guests.

Copenhagen

Three days were spent in Copenhagen, of which two were devoted to visiting the new Orthopaedic Hospital on the outskirts of the city. An attractive program was arranged by Dr. Paul Guildal and his colleagues and consisted of operative demonstrations and presentations of short papers.

Dr. Guildal gave an account of the functions of the Danish Orthopaedic Hospital, outlining the origin and progress of the treatment of the crippled child in Denmark. The whole service in Copenhagen is financed by the State and the medical staff are all salaried officials. In a second paper Dr. Guildal gave an interesting résumé of the principles and results of the orthopaedic treatment of infantile paralysis. His practice and results corresponded closely with British views on this subject.

Dr. Bentzon advocated the use of drilling osteoclasis in preference to osteotomy for the correction chiefly of outward curvature of the tibiae due to rickets. Through a tiny incision, multiple drill holes are made in a transverse line at the apex of the deformity. The bone is then broken manually or with an osteoclast.

Dr. Bentzon also demonstrated the result of an operation for gluteus-medius palsy. The procedure consists of transferring the insertion of the upper two-thirds of the gluteus maximus upward and forward to occupy a true lateral position on the crest of the ilium. An excellent result had been obtained in the patient whom he showed, for the patient walked without a trace of limp and could stand on the affected leg with perfect balance.

Dr. Kiaer made some remarks on the treatment of joint contractures. He had found very helpful a combination of infiltration of the capsule of the affected joint with local anaesthesia and active mobilization. He suggested that similar methods could be employed usefully in the treatment of recent sprains and of painful scars. He also showed two patients after treatment for sciatic scoliosis. He commented on the difficulties of establishing any cause for the condition, and stated that he had found that immobilization of the lumbosacral spine in a plaster-of-Paris jacket, applied with the patient suspended or bending forward, gave the most satisfactory results.

Dr. Staermose gave a brief review of calcaneonavicular fusion. Although in many people this condition represents no more than a symptomless anatomical anomaly, yet it is occasionally found in association with spasmodic flat-foot. Excision of the bridge between the two bones and the interposition of part of the muscle belly of the extensor digitorum brevis usually results in cure of the peroneal spasm.

Dr. Foged showed many results of operations for torticollis. He found that the most universally satisfactory procedure had been open division of both heads of the sternomastoid just above the clavicle, followed by a long period of daily stretching and reeducation.

Dr. Chievitz gave an account of the geographical distribution of tuberculosis among the Danish population and discussed the relationship between human and bovine types

in surgical lesions. The majority of these were due to the bovine type. A brief symposium on osteo-arthritis of the hip followed:

Dr. Morville dealt in a clear, concise way with the classification of this disease from the clinical and roentgenological standpoints.

Dr. Berntsen described his method of drilling (*"forage"*) the femoral neck and head, the procedure described originally by Graber-Duvernay. It was interesting to hear that very considerable relief of pain had followed this simple operation in over 60 per cent. of his series of patients suffering from osteo-arthritis of the hip.

Dr. Therkelsen discussed in great detail the indications for and the results of "shelf" operations performed in adult life for congenital subluxations of the hip. In contrast with the experience of British surgeons, Dr. Therkelsen had found the operation satisfactory in relieving pain and in increasing stability of the hip.

The British Orthopaedic Association dinner was held at the Restaurant Nimb and the guests included the Danish contingent.

Stockholm

In this city two mornings were spent at the new *Karolinska Institutets Orthopediska Klinik Vanföreanstalten* where Prof. Waldenström and his colleagues and assistants presented a most stimulating program.

Prof. Waldenström showed the results which he had obtained from arthroplasties on various joints. Concerning arthroplasties in general, Prof. Waldenström stated that the difficulty lies not only in carrying out the operation skilfully, but also in deciding which cases are suitable for operation. The patients are kept in the hospital for some time before making a decision, not only for the purposes of physical examination, but also, which is still more important, to get an impression of their mentality and their reaction. The postoperative treatment is painful, and the patient must not only submit to passive movements, but he must also carry out energetic active ones many times each day in spite of pain.

Prof. Waldenström also presented some of his views on certain hip conditions of which he has made a life-long study. These include coxa plana (pseudocoxalgia) and coxa magna-valga-luxans. He attributes the latter to a mild local inflammatory process, possibly tuberculous in some patients, which results in overgrowth of the femoral head, so that it is no longer contained completely within the acetabulum. The relationship between osteo-arthritis and the congenital and youthfully acquired deformations of the femoral head were discussed.

Prof. Waldenström also performed an operation for recurrent dislocation of the shoulder,—the insertion of an autogenous bone graft into a niche along the anterior margin of the glenoid (Eden-Hybbinette operation).

Dr. Friberg read a paper on spondylolisthesis. If symptoms are present, he advocates fusion of the slipping vertebral body to the spinal segment immediately distal to it, through an abdominal transperitoneal approach. Dr. Friberg performed his own modification of this operation on a patient during the course of the meeting.

Dr. Knutsson gave a brief but detailed account of the roentgenographic findings in sacralization of the fifth lumbar vertebra. He emphasized the fact that symptoms could arise not only from arthritis in the joint between the sacralized transverse process and the sacrum, but also from arthritis in the smaller intervertebral joints of the lower lumbar segments.

Dr. Silfverskiöld described the condition known as chondromalacia patellae and its treatment. He regards it as the most common form of internal derangement of the knee and believes that the cartilage of the patella is the first in the body to undergo degenerative changes. The clinical picture consists of crepitations between the patella and femur on movement, associated with attacks of pain and swelling and peripatellar tenderness. For mild lesions he advises conservative measures and for more advanced ones, excision of the damaged cartilage in part, or in whole, covering the raw area with a free fascial

graft. About seventy patients have been operated on and the majority have perfect function. Some of them were demonstrated.

Dr. Nilsonne gave an account of the results of the operative treatment of infantile or congenital coxa vara and presented some patients. He has performed a wedge osteotomy in the trochanteric region on sixty patients suffering from this condition. His best results have been obtained in those patients on whom the osteotomy was done between the ages of six and eight. In these circumstances successive roentgenograms showed that the femoral neck had reconstructed itself over a number of years until eventually the hip could not be distinguished from the normal either by clinical or roentgenographic examination.

Miss Hojer, Director of the Cripples Educational and Training Establishment, gave a most clear account of the arrangements in Sweden for the rehabilitation of the cripple and for his engagement in a lucrative occupation. The whole scheme, which embraces workshops, boarding schools, and salaried social workers, is subsidized by the State Grants up to about half of the total expense.

Other short papers were read on the syndrome of the scalenus anticus and cervical rib by Dr. Wiberg, on congenital ulnar deviation of the fingers, by Dr. Lundblom, and on the results of the shelf operation for congenital subluxation of the hip in adults by Dr. Severin.

The British Orthopaedic Association dinner was held at the Hasselbacken restaurant. The local orthopaedic contingent and several other distinguished members of the Stockholm medical profession, including Prof. Key, were guests.

Social entertainment for the visitors and their guests was well organized and included tours to all the places of interest, and these are many, in and around Stockholm. The weather was perfect and everyone was unstinting in praise for this beautiful city. No one who participated is likely ever to forget the experience of dining as the guests of Prof. and Mrs. Waldenström at Hoganloft, Skansen, amid the charming setting of an ancient Swedish house with old folk dances on the lawn lighted only by flaming log fires.

At a recent meeting of the Executive Committee, the following were elected to Associate Membership in the **British Orthopaedic Association:**

Mr. C. Lee-Pattison, King Edward VII Hospital, Rivelin Valley Road, Sheffield 6, England

Mr. R. C. Murray, The Royal Infirmary, Liverpool 3, England

Mr. A. M. Rennie, Wester, Furtray, Kintore, Aberdeenshire, Scotland

Mr. F. H. Aitken Walker, 16 Westcote Road, Reading, Berks., England.

Correction

Dr. Emanuel B. Kaplan of New York has requested that we publish a correction in his article entitled "Extension Deformities of the Proximal Interphalangeal Joints of the Fingers" published in *The Journal* for July 1936. The fifth line of the first full paragraph on page 783 should read "the bifurcation of the sublimis tendon were cut across the joint".

Current Literature

TRAITÉ DE CHIRURGIE ORTHOPÉDIQUE. L. Ombrédanne et P. Mathieu. (En 5 Volumes.) Paris, Masson et C^ie^, 1937. Chaque tome, 300 francs; les 5 volumes, 1500 francs.

Volumes III, IV, and V of the series (a review of Volumes I and II appeared in *The Journal* for July 1937) complete this very comprehensive treatise which has considered practically all of the conditions of interest to the orthopaedic surgeon and to the traumatologist, as well as to a large number of surgeons and medical men who are thrown in contact with these conditions.

The third volume begins with a chapter on tumors of the spine, both secondary and primary, the majority of which are considered malignant, also the parasitic tumors. With this chapter ends the portion of the series which deals with the region of the spine. The remainder of the volume is given to the upper extremity,—the scapular girdle, the scapula (with some affections of the thorax), the shoulder, the upper arm, the elbow, the lower arm, the wrist, and the hand. The affections and the traumata which occur in each region are considered, especially the fractures and dislocations with fractures involving the joints, as well as the derangements of the joints. The diagnosis, including the roentgenographic interpretation, and the conservative and operative treatment have been thoroughly considered. The discussion of the joints includes many of the tuberculous affections, but emphasis is given to the traumatic conditions. To the affections involving the wrist, and especially the hand, a much larger space is accorded than is usual in this form of treatise, and the consideration of many of the smaller difficulties, such as trigger-finger, adds to the practical value.

The fourth volume takes up the pelvic girdle and discusses the anomalies, fractures, and dislocations, with a consideration of the mortality which occurs in these severe traumatic conditions. The infectious lesions of this region (osteomyelitis and tuberculosis) are presented with a discussion of the pathology, clinical course, prognosis, and treatment. This is particularly helpful because of the severe complications, difficult to treat, which are met with in this group. The affections of the hip, including the congenital conditions and the dystrophies, also the traumatic and infectious lesions, are treated in the same manner. Fractures of the thigh are also given a place. A discussion of the affections of the knee completes the volume. Here, as in the rest of the work, emphasis is placed on the traumatic sequelae and the conditions requiring active and operative treatment, but the lesser conditions and the conservative treatment are not neglected.

Volume V is occupied with a consideration of some of the affections of the leg which are not covered in Volume IV, and with a discussion of roentgenograms of young and developing bone and of congenital pseudarthrosis, including fractures of the lower leg. The affections of the foot and the tibio-astragalar joint, including both congenital and acquired deformities and fractures, occupy a large part of the volume. The etiology and the roentgenographic determination of these deformities are considered, followed by the discussion of the treatment, in which both conservative and operative methods are evaluated. The operative treatment seems to be more favored, but this is a part of the modern trend in medicine and surgery. In the last portion of the fifth volume, the technique of amputations and directions with regard to prostheses are given, followed by a discussion of the paralyses of the upper and lower extremities with a consideration of the treatment, both conservative and operative.

The authors state that in these five volumes the effort has been made to avoid the common error of presenting too much of personal opinion, and to this end they have obtained the collaboration of a large number of surgeons of extensive experience. It is recognized that in the present state of knowledge no one can possess the best in each

department, even in his own specialty, therefore the work has been distributed among a large number of contributors, each of whom has been chosen with reference to his particular experience with the special subject which has been assigned to him. Also, a very complete bibliography for each subject is added, to render a more complete representation of the present status of each. Each contributor has given full recognition to the advances which have been made by workers in other countries. At the same time, these collaborators have presented the present status of the advance of knowledge which has resulted from the work of those in their own country, hoping that by this many outside their borders may recognize what has been accomplished by the French orthopaedic surgeons.

Throughout the books the authors' opinions and experiences are evident, and this adds to the interest as well as to the value of the presentation of the different subjects. The books are profusely illustrated with excellent roentgenograms, and, according to the prevailing custom, line drawings are used to clarify the interpretation of many of these roentgenograms. The different stages of the operations are also shown by excellent drawings. These five interesting volumes constitute a very valuable series.

ROSE & CARLESS MANUAL OF SURGERY. Edited by William T. Coughlin, M.D. American (Fifteenth) Edition. Baltimore, William Wood & Company, 1937. $9.00.

Dedicated to Lord Lister, under whom Carless, one of the original writers, worked, this book now appears in its fifteenth edition. It was first published in 1898 and has been translated into the Hungarian, Chinese, and Arabic languages. This American edition has been arranged from the new English edition prepared by Cecil P. G. Wakeley and John B. Hunter, and certain sections relating to the specialties have been omitted. Many chapters have been completely rewritten,—considerable new material has been added and obsolete matter has been eliminated. New chapters appear on "Surgical Shock" and "Surgery of the Central Nervous System".

The text is printed on excellent paper. The titles and subtitles, such as "Treatment" and "Etiology", appear in bold-face print, making it easy to pick out the desired sections readily. There are many full-page colored drawings which, together with the photographs interspersed with the text, are clear and very interesting.

The arrangement of the subject matter by chapters is well done. The first chapters deal with infections, inflammation and repair, the blood, pyogenic infections and infected wounds, ulceration, necrosis and gangrene, and specific infections. Then appears a fairly good outline of tumors and cysts and their treatment. The chapter on "The Use of Physical Agencies in Surgery" is interesting and is usually lacking in surgical treatises. The discussion of radium is especially well written and well illustrated.

Fifty pages are devoted to deformities and orthopaedic surgery and twice as many pages to fractures. The latter section is probably the best in the book. The pathology of fractures, the mechanism of occurrence, and the methods of treatment are thoroughly discussed and well illustrated. The use of fascia in the repair of fractures of the patella and of the olecranon is not included. No mention is made of the use of antitetanic serum or gas-gangrene vaccine in the section on compound fractures, although a full discussion of these drugs appears in the section on infected wounds. The statement is made that Lane plates are now but rarely used. One objection to their use is that "absolute fixity of the fragments without the possibility of the slightest movement does not conduce to rapid or effective healing; the best results are secured when it is possible for the ends to rub one against the other without displacement". These statements might be refuted by some American surgeons.

In the section on cancer of the breast there are excellent drawings showing the proper way to palpate the breast and the axilla. The text points out the need of radical removal of the breast, but the accompanying illustration shows a circular incision which does not even remove the whole breast.

The statement is made that cancer of the lip is commonly due to irritation produced

by smoking a short clay pipe. That feeling is not held in this country where the clay pipe has practically disappeared, and where cigarette smokers have displaced the pipe smokers, but without eliminating the cancers of the lip.

This is an excellent treatise on surgery. The present edition is far ahead of the previous ones, all of which have been good. It is thoroughly up to date, as all of the latest subjects have been considered.

DIE ANATOMIE DER ANGEBORENEN HÜFTVERRENKUNG (The Anatomy of Congenital Dislocation of the Hip). Prof. Dr. V. Putti. Stuttgart, Ferdinand Enke, 1937. 82 marks.

This is a translation by Prof. Dr. G. A. Wollenberg and Dr. H. Wolff of the work by Prof. Putti published in Italian.

A book by Prof. Putti on the subject of congenital dislocation of the hip needs no comment except one of congratulation to the medical public on the privilege of possessing such a volume. The result of Prof. Putti's studies and experience with this affection is always welcome, and this edition is no exception. In an elaborate volume of full folio size, with twenty pages of text and seventy-seven pages of illustrations, Prof. Putti has presented by a "rivulet of text and a meadow of illustrations" the information which should lead his readers to a most complete understanding of this subject.

He stresses the need of familiarity with the normal anatomy and the variations from the normal in these cases, and he includes a careful description of the normal anatomy of this whole region and a discussion of its bearing on that found in congenital dislocation, together with the abnormal anatomy and the varied malrelations and abnormal structures which are found in these cases. Each part of the joint is described with the special object of defining its importance in the formation of the deformity and its influence in obtaining reduction and retention, so that it may be given sufficient recognition in the treatment.

As a rule, it is not possible to study in detail these features of this deformity, but Prof. Putti has taken advantage of exceptional opportunities which have come to him. In the cases in which reduction has been performed, the anatomy of each structure with its relation to the joint is shown. Many of the illustrations are photographs of dissections in cases which have been operated upon, and they show the actual conditions which exist. These add very definitely to the understanding of this condition and serve as guides to the operator. Roentgenograms, accompanied by line drawings, demonstrate the form and relation of the parts of the joint both before and after operation, as well as the large variety of the types of dislocation. There are also portrayed the sequelae from the deformity of the head which are so often found several years after reduction. Unusual illustrations in color show the different steps of the operation of open reduction.

It is seldom that one finds a subject treated so thoroughly and accurately and presented in such an excellent manner.

INJURIES AND DISEASES OF THE HIP. SURGERY AND CONSERVATIVE TREATMENT. Fred H. Albee, M.D., LL.D., F.A.C.S. Assisted by Robert L. Preston, M.D. New York, Paul B. Hoeber, Inc., 1937. $5.50.

In the preface, Dr. Albee states that in compiling the material for the book he included all procedures, conservative and operative, which he uses, as well as certain procedures which he does not use but which are commonly employed by surgeons of experience and mature judgment. He states that the bibliography is selective and usable rather than complete. The author quotes directly from the published articles of other writers when he presents their methods. This has the merit of accuracy, although it is perhaps rather tedious for the average reader. The author is quite frank in his frequent claims for priority in a number of procedures, but priority is a matter of record and is uninteresting and unimportant to readers.

There is very little that one can actually criticize in the book when it is remembered

that it is fundamentally a monograph based upon the author's personal experience. In fact this personal phase gives the book its value, for no man living today has done more than Dr. Albee to advance bone surgery. Accordingly, his chapter on armamentarium of the surgeon for hip work is interesting and instructive.

Albee advises the use of the autogenous bone peg rather than the Smith-Petersen nail in recent fractures of the neck of the femur. For old ununited fractures he advocates thorough removal of the fibrous tissue between the fragments, thorough freshening and fitting of bone surfaces, and insertion of an autogenous bone peg. For cases of long standing with much erosion of fragments and malnourishment of the capital fragment, Albee advises strongly his reconstruction operation. This operation consists of two steps: First, the head of the femur is excised and the remnant of the neck is smoothed down and inserted in the acetabulum; second, osteotomes are driven from above downward through the trochanter vertically to pry outward a good-sized piece of the trochanter (a greenstick fracture), and between it and the major portion of the trochanter the denuded and freshened head is inserted to act as a fulcrum. This piece of trochanter thus pried outward provides a lever to which the trochanteric muscles are attached. Albee lays great stress on this lever action and uses the same principle in his arthroplasties, the fulcrum being provided by pieces of bone from the iliac wall wedged into the trochanteric cleft.

For congenital dislocations of the hip he prefers closed reduction and sees no necessity for open procedures except in older children and in the more resistant cases. He favors arthrodesis for tuberculosis of the hip in adults and outlines several types of operations. First, where destruction is moderate and the neck long, he advises an extra-articular bone graft taken from the tibia or the upper end of the femur. Second, where destruction is greater and the trochanter is approximated to the ilium, he advises taking the graft from the iliac wall or using the trochanter, somewhat after the manner of Hibbs. For children, conservatism should be adhered to. (One wonders why the word "echor" is used instead of abscess. It is little known to American readers.)

Other conditions—synovitis, arthritis, ankylosis, coxa vara, osteo-arthritis, etc.—are dealt with in the same interesting personal way. The book is readable and one that every orthopaedic surgeon will be interested in. The author and Dr. Preston who assisted him are to be congratulated in giving us an interesting book on a field of surgery about which little has been written.

This book of 298 pages, beautifully printed on fine paper, is a credit to the publisher.

LA SPONDYLOLYSE ET SES CONSÉQUENCES. SPONDYLOLISTHÉSIS—SCOLIOSE LISTHÉSIQUE. Pierre Glorieux et Carle Roederer. Paris, Masson et C^{ie}, 1937. 60 fr.

The authors have presented this subject under the term of spondylolysis, which includes any solution of continuity in the posterior vertebral area, but which has too often been regarded as confined only to spondylolisthesis.

The authors have gone into the subject of the etiology with especial thoroughness by the consideration of the anatomical factors and their relation to the etiology. They point out the large area in which these anatomical variations or defects may be distributed, and it is shown that this condition in reality occupies a much larger field than that which is usually covered by writers on this subject.

Among the complications which the authors have considered, spondylolisthesis has special attention, but the varieties and areas of the different displacements are also treated in detail, and it is of value to have these grouped in the general discussion of this one subject, for as a rule they are not given sufficient prominence. It is shown that these displacements may be due either to a congenital anomaly or to a lesion.

The chapter dealing with the clinical and roentgenographic diagnosis the reader will find full of practical and valuable information. The clinical symptoms and the physical examination give the first evidence of the existence of the abnormalities, which must be later confirmed and the exact localization determined by the roentgenogram. The

portion of the book dealing with the roentgenographic diagnosis is most carefully and completely presented, and the interpretation of the shadows, with their significance, is discussed in a thorough and clear manner. The roentgenograms are nearly all accompanied by very excellent line drawings illustrating the anatomical position of the defects. The detection of the anatomical conditions by roentgenograms taken at different angles has also been given prominence; this is a feature of much importance for frequently these defects can be detected by the use of anteroposterior or lateral rays. All of this is necessary, for the interpretation of the shadows is particularly difficult, and the important part they play in diagnosis makes essential such a treatment of this part of the subject.

A chapter is then devoted to that form of scoliosis which has its origin in this condition, "*scoliose listhésique*", and many examples of the variations found in this type are given.

The chapter on treatment covers the field fully,—first the cases which do not need treatment are discussed and then the conservative and operative methods are considered. The object and limitations of the conservative treatment are given necessary importance. The operative measures receive more space, and all the various operative methods are explained, including operations on the anterior portion of the spine.

The book is copiously illustrated by excellent roentgenograms, of which a large number are accompanied by line drawings of the structures which are shown. The book is evidently the result of long study and is full of practical information.

SPORTSCHÄDEN UND SPORTVERLETZUNGEN (Accidents and Injuries from Sports). Prof. Dr. Burghard Breitner. (Neue Deutsche Chirurgie, LVIII.) Stuttgart, Ferdinand Enke, 1937. 16 marks.

This 173-page book is written by the head of the surgical clinic in the center of Europe's most active winter-sport region. Breitner gives an introductory review of the historical development of athletics and their philosophical significance. Athletics should aim at the performance which is best for the individual and not at maximal accomplishment of the human machine. Properly supervised sport has no hazards peculiar to it, and statistical surveys show the occurrence of accidents to be relatively infrequent. About 75 per cent. of all ski injuries occur among beginners; accidents decrease as the factors of intention and execution become correlated. The greatest single cause of athletic injury is a feeling of fear or underconfidence.

The major part of the book is devoted to the injuries common to each of the various branches of sport, from walking to flying (the chemical content of an exploding golf ball is not omitted!); and injuries are then discussed in their classification by anatomical location. This is followed by a section on the treatment of the more frequent injuries.

Breitner's book surveys a broad field and is based on an extensive bibliography. It is a comprehensive review of the subject of athletic injuries, written in a flowing, lucid style, at the same time emphasizing many essential points. The sections of the book are subdivided under clear titles and the numerous references given in each section are valuable guides to the study of the various topics included.

FRACTURAS Y LUXACIONES. Terencio Gioia. Tomo II. Buenos Aires, Aniceto Lopez, 1934.

In this second volume, a book of 670 pages, Prof. Gioia has presented a very thorough discussion of the subject of fractures and dislocations of the cranium, the face, and the spine. The subject of fractures and dislocations of the extremities will be considered in Volume III soon to be published.

In discussing the fractures and dislocations which occur in each of these three regions, the author considers the manner of occurrence, the etiology, the diagnosis, and the treatment. The many varieties of fracture of the skull, the method of occurrence (including gunshot wounds), and the treatment are especially well presented. He also discusses

the sequelae of the trauma which may cause serious complications that are difficult to treat, and this adds very definitely to the practical value of the work. The operative procedures, particularly those used in the first and second regions, are given sufficient prominence, and the different steps of the operations are illustrated by excellent photographs and drawings, some of which are in color. Fractures and dislocations of the spine, both singly and combined, are dealt with in the last section. There are excellent line drawings to help in the interpretation of the x-ray shadows. The conservative treatment of fractures of the spine is also emphasized, and methods of correction and retention are well described and illustrated.

Volume III of this series should be most welcome.

HOFFA-GOCHT TECHNIK DER MASSAGE. Doz. Dr. Hans Storck. 9 Aufl. Stuttgart, Ferdinand Enke, 1937. 8.60 marks.

This volume of 123 pages, originally written by Hoffa-Gocht, appears in its ninth revised edition from the pen of Dr. Hans Storck of the Orthopaedic Clinic of Berlin University. The technique of massage is ably and clearly discussed. The description of the various methods is similar to that found in American text-books. In the preface, and even more in the chapter on the physiological effects of massage, the present author faces his most difficult problem,—a discussion of the scientific basis for massage and a description in physiological terms of the effects which it produces. The experimental data are well presented but they are not adequate. One feels that here is a field for study and research that would give much worth-while data which could be applied in physiotherapeutic medicine.

The various procedures are well illustrated by good line drawings. A number of anatomical plates to illustrate the massage of various groups of muscles are also given. The general arrangement of the book is commendable. The subjects follow each other in logical sequence, and the author describes as lucidly as is possible methods of treatment which can be learned only by example. It should prove to be a useful reference book for physicians and physiotherapists as well as a supplementary text-book for students.

THE TECHNIC OF LOCAL ANESTHESIA. Arthur E. Hertzler, A.M., M.D., Ph.D., LL.D., F.A.C.S. Ed. 6. St. Louis, The C. V. Mosby Company, 1937. $5.00.

The sixth edition of Hertzler's work on local anaesthesia comes to hand in a well-printed volume with 142 illustrations which should assist the would-be employer of the techniques in selecting sites for the introduction of needles to anaesthetize practically any region of the body where local methods are at all applicable.

After a short discussion of the best drugs to employ, their limits of usefulness, and the methods of administration, there follow a few pages on minor operations, such as the opening of abscesses, the removal of tumors (circumscribed benign, infiltrating localized, and malignant), the search for foreign bodies, skin grafting and the suturing of wounds.

From Chapter IV to the section on spinal anaesthesia, the subject is treated regionally. Certain operations in the abdomen are included within the field of local anaesthesia, although the author would, in general, restrict operations upon the viscera to spinal anaesthesia, paravertebral and splanchnic methods having been replaced by spinal anaesthesia. Nerve blocking in the case of the sacral nerves is given a few pages of description, but the author feels that the chance of hitting all the sacral foramina is quite problematic. Spinal anaesthesia is fully described and its complications are considered. Then follows a discussion of local infiltration anaesthesia for herniae; for operations upon the external genitalia, the bladder, the prostate; for repair work on the female genitalia; for hemorrhoids and fistulae; and, finally, for the minor amputations on the hand and foot,—hallux valgus and ingrowing toenails.

It may be that all this can be accomplished with the ease and general surgical satisfaction that the author would seem to have experienced, but it is notable in reading the

text that there is a frequently recurring admonition to the effect that if the operator does not feel that he has sufficient mastery of the technique to undertake a given operation as described, he had best resort to some other method.

DIE DRAHTEXTENSION. ANLEITUNG ZUM PRAKTISCHEN GEBRAUCH. (Wire Extension. A Guide to Practical Use.) Prof. Dr. Rudolph Klapp und Dr. W. Rückert. Stuttgart, Ferdinand Enke, 1937. 15.80 marks.

As a successor to nail extension, wire traction has been developed through many refinements. This monograph presents the modern technique, including choice of wire, shape of the point, type of guide, and fixation device. Lateral traction by use of a cannula or by beaded or threaded wire is emphasized. A chart of sites of insertion is given. Pitfalls and complications are enumerated.

The application of the method to individual topographically arranged fractures is illustrated by photographs, roentgenograms, and many excellent diagrams. The technique is given also for the treatment of contractures, subluxations, and complicated wounds by wire traction.

This compact manual of 144 pages with 185 well-labeled illustrations is a pictorial exposition of the subject elaborated by well-chosen paragraphs which are subheaded for greater ease of reading. It is a practical and most valuable addition to the subject of skeletal traction.

A TEXTBOOK OF SURGICAL NURSING. Henry S. Brookes, Jr., M.D. St. Louis, The C. V. Mosby Company, 1937. $3.50.

There are many features to commend this book as a guide for the nurse interested in surgical nursing. Possibly there is an undue amount of space given to the descriptions and illustrations of operations and surgical conditions which are the particular concern of the surgeon. This is, of course, interesting and helpful to the nurse, but one wishes that more might have been said of the actual place of the nurse in the work.

The first part of the book contains the kind of material needed for the teaching of student nurses,—the discussion of inflammation and infections; the various kinds of burns, wounds and tumors; and the preparation of dressings and bandages. The chapter on preoperative and postoperative care—perhaps the most important phase of surgical nursing—is well done as is also the chapter on postoperative complications. One would also commend particularly the chapter on fractures and dislocations. The care of the various types of orthopaedic cases requires good intelligent nursing quite as much as—perhaps more than—the usual postoperative cases, both because of the length of the illness and because of the mental condition of the patient who is more or less helpless for a long period. Nursing of these cases is surely the test of a good nurse, and requires careful instruction and supervision on the part of those who are teaching student nurses. Much helpful information on the nursing care of such cases is included in this book.

Some of the procedures described in the chapter on special procedures could be omitted from this particular text, inasmuch as they may be included in medical as well as in surgical nursing, and should be taught the young student early in her course before she is able to carry out the more advanced specialized techniques. The same might be said of some of the diets described. Although the glossary repeats terms already familiar to the student nurse or available to her in her medical dictionary, the words are well selected in relation to this text and deserve the special emphasis here given.

Among the outstanding features of the book are the illustrations which are unusually good and very well selected.

SHORT-WAVE DIATHERMY. Tibor de Cholnoky. New York, Columbia University Press, 1937. $4.00.

Short-wave diathermy has been so generally employed in recent years that an authoritative discussion of the way it has been studied and brought to its present state of reliability is very timely. This book represents a study of more than 700 articles appear-

ing in the literature of the past eight years, including the experimental work that has been done by a great number of research students, physicists, and electrotherapeutists. It is a thoroughly critical review and leaves the impression that the author has approached his task in an unbiased attitude.

As the author points out, there is still so much to be learned in respect to tissue resistance—the specificity of certain wave lengths for certain types of tissue and the changes in tissue resistance to the passage of short waves, depending upon the pathology of the tissues to be treated—that one cannot be too positive in one's claims for the value of the method. What can be stated with some degree of finality is that to date the beneficial effects that may be attributed to its use are due to heat and that in the hands of a specialist it is the best way of applying heat locally to deep-seated tissues. Of the various types of lesions where it has proved most efficacious, the inflammatory lesions (acute, subacute, and chronic) are the best prospects for relief. It is a worth-while book for anyone who wishes to make intelligent use of this type of physiotherapy.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Acta Paediatrica, XIX, Fasc. 1, 2, and 3, Supplementum I, 1936–1937.

Anales de la Facultad de Ciencias Medicas de la Plata (Buenos Aires), I, 1937.

Annaes Paulistas de Medicina e Cirurgia (São Paulo), XXXIII, No. 5, 1937.

Archivos de la Sociedad de Cirujanos de Hospital (Santiago de Chile), VII, Nos. 1, 2, and 3, 1937.

Bethesda (Pittsburgh, Penna.), XXXIX, No. 3, 1937.

Boletim Clinico e de Estatistica dos Hospitais Civis de Lisboa (Lisbon), I, No. 1, 1937.

Boletim da Secretaria Geral de Saude e Assistencia (Rio de Janeiro), II, Num. 4, 1936.

Boletin del Centro Antirreumatico (Buenos Aires), I, Num. 1, 1937.

Boletin de los Hospitales (Caracas), XXXV, No. 9, 1937.

Boletines de la Sociedad de Cirugía de Rosario, III, Nos. 7 and 8, 1936.

Bollettino e Atti della Reale Accademia Medica di Roma, LXIII, Fasc. 1–4, 1937.

Bulletin of the National Tuberculosis Association, XXIII, Nos. 8 and 9, 1937.

The Child (Washington, D. C.), I, 1936–1937; II, Nos. 1 and 2, 1937.

*Chronic Rheumatic Diseases, Being the Third Annual Report of the British Committee on Chronic Rheumatic Diseases Appointed by the Royal College of Physicians. Edited by C. W. Buckley, M.D., F.R.C.P. New York, The Macmillan Company, 1937.

Cirurgía y Cirujanos (Mexico, D.F.), V, Núm. 5, 1937.

Cleveland Clinic Quarterly, IV, Nos. 2 and 3, 1937.

Current Medicine, IV, Nos. 6 and 8, 1937.

Health Shoes, II, No. 10, 1937.

Hospital for Joint Diseases of the City of New York. Thirtieth Annual Report for the Year 1936. New York, 1937.

The Johns Hopkins University Circular. School of Hygiene and Public Health, Catalogue Number 1937–1938. Baltimore, 1937.

Mundo Medico (Rio de Janeiro), XI, Nums. 495–501, 1937.

Radiography and Clinical Photography, XIII, Nos. 2 and 3, 1937.

Revista de Cirugia Hospital Juarez (Mexico, D.F.), VIII, Num. 7, 1937.

Roche Review, I, Nos. 8, 9, 10, 11, and 12, 1937.

Roma y Moscu. Impresiones de un Cirujano Argentino. Prof. Lelio Zeno. Rosario, Talleres Gráficos "Fenner", 1937.

Tissue Reactions in Bone and Dentine. A Morpho-Biological Study of the Formation and the Dissolving of Bone and Dentine. Åke Wilton, M.D. London, Henry Kimpton, 1937.

* To be reviewed in a subsequent issue.

University of Chicago Medical Schools. Announcements for the Sessions of 1937–1938, XXXVII, No. 14, 1937.

Upsala Läkareförenings förhandlingar, XLII, Häft. 1–6, 1936–1937.

Verzeichnis der Ärztekurse im Studienjahre 1937–1938. Das Kursbüro der Wiener Medizinischen Fakultät. Vienna, 1937.

TEN OPERATED CASES OF INJURIES TO THE CRUCIAL LIGAMENTS IN THE KNEE JOINT. Ivar Palmer. *Acta Chirurgica Scandinavica*, LXXIX, 391, 1937.

Ruptured cruciate ligaments probably do not heal spontaneously. The writer advocates early suture with silk. He reports six operations in such recent cases of injury. Of these patients, one died of embolism, but five showed complete or almost complete restitution to normal motion with a negative "drawer" sign. Four chronic cases were operated upon, and a graft of tendon or fascia was inserted. Two patients were symptom-free, one was improved, and in one the knee was stable but much reduced in motion as the result of a second operation. The writer calls attention to the relative magnitude of the late operation. It is contra-indicated when the collateral ligaments are damaged or when there are secondary degenerative joint changes.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

INSERTION OF SMITH-PETERSEN NAIL FOR INTRACAPSULAR FRACTURES OF NECK OF FEMUR. J. Albert Key. *American Journal of Surgery*, XXXVI, 466, May 1937.

The author has attempted to simplify the method of introduction of the nail by avoiding complicated apparatus. The fracture is reduced by the Leadbetter method, which assures accuracy of the reduction. Check-up roentgenograms of both the anteroposterior and lateral views are taken. Local anaesthesia of 1-per-cent. novocain is used in combination with either avertin or morphine. A six-inch incision is made over the lateral surface of the femur from the tip of the trochanter. A drill, described as a three-sixteenths-inch twist drill, carpenter's type, six inches long, is inserted about three inches. The angle and depth are then checked by a second series of roentgenograms. The nail is selected and driven into place along the drill hole, after removal of the drill, or higher or lower than the position of the drill, as the case may be, so as to penetrate the head and neck a little below the midline. The distal fragment is firmly impacted upon the head, and the position checked with a third series of roentgenograms. No postoperative fixation is used. Slight overreduction is preferable. Weight-bearing is allowed one month after operation, but crutches are used for at least three months.—*Custis Lee Hall, M.D., Washington, D. C.*

CORKSCREW-BOLT FOR COMPRESSION-FIXATION OF FEMORAL NECK FRACTURES. Robert K. Lippmann. *American Journal of Surgery*, XXXVII, 79, July 1937.

Six cases of intracapsular fracture are reported and indicate that accurate insertion can be accomplished by roentgenographic or fluoroscopic control. The device is a corkscrew of reduced pitch, with four turns, devised to hold the capital fragment, the diameter being three-eighths to one-half an inch. No preliminary drilling is done and no wires are used. The author claims mechanical efficiency in holding cancellous bone. At the end of the bolt are threads, with a trochanter catch for impacting the fracture. The middle portions of the bolt are smooth. This mechanism also prevents rotation of the instrument, the catch being impacted into the trochanter and held tightly by a nut on the shaft. Hip reduction was by the Leadbetter method and a small incision below the trochanter was used to reach the shaft of the femur. No postoperative fixation was used except in the first cases. Function and stability shortly after operation indicate that security of fixation may be as dependable as bony union long before union is possible. The corkscrew bolt of the author is markedly similar to a threaded bolt used at the *Istituto Rizzoli* by Putti, and now in the developmental stage.—*Custis Lee Hall, M.D., Washington, D. C.*

CLINICAL OSTEOMYELITIS OF LONG BONES. Rodney F. Atsatt. *American Journal of Surgery*, XXXVII, 291, August 1937.

The author discusses four types of osteomyelitis,—the simple, delayed, chronic, and septic. Six cases illustrating these types are given in detail, with a description of both the radical and conservative methods used. Supportive measures were intravenous fluids, metaphen, and prontylin, supplemented with blood transfusions where indicated. There was one fatal case in the septic group. Postoperative treatment consisted of the usual Orr vaselin pack and plaster fixation.—*Custis Lee Hall, M.D., Washington, D. C.*

TRAUMATIC SEPARATION OF EPIPHYSIS OF LOWER END OF FEMUR. Harold Bellin. *American Journal of Surgery*, XXXVII, 306, August 1937.

After a review of the literature, which includes more than 200 cases, the author reports one case. He calls attention to the need for roentgenographic examination in order to make accurate diagnosis of this injury. Reduction was easily accomplished by acute flexion of the knee which was maintained until healing and followed by extension manipulation. The end result, four years later, indicates a crepitation in the joint, thickening of the epiphysis, knock-knee tendency, with a lengthening of the leg of one inch.—*Custis Lee Hall, M.D., Washington, D. C.*

SHORT NOTES ON ARTHRITIS. B. B. Battacharjee. *The Antispetic*, XXXIV, 468, 1937.

The author presents a series of brief notes on his experience in the treatment of arthritis, which he classifies under twelve etiological types. He notes that the pneumonic type of arthritis affects the upper extremities more than the lower, and larger joints more than smaller ones. Consideration is given chiefly to gonorrhoeal arthritis, in the treatment of which the author apparently relies on potassium iodide, sodium salicilate, acid sodium phosphate, morphine, and injections of fresh sterilized milk.—*Robert M. Green, M.D., Boston, Massachusetts.*

PAINFUL COCCYX. George A. Duncan. *Archives of Surgery*, XXXIV, 1088, June 1937.

After a brief survey of the history, anatomy, and etiology of coccygodynia, the author considers the various theories for this pain. He then discusses the clinical course and treatment of painful coccyx based on a study of 278 patients seen in the New York Orthopaedic Dispensary and Hospital. He is of the opinion that trauma is the explanation for most of these incidences and that the diagnosis of neurasthenia "is an admission of defeat on the part of the physician". In general the injection treatment has been found unsatisfactory. Postural correction, local heat, and local massage constituted the usual non-operative therapeutic methods, and gave relief to a very large percentage of the patients. He advocates conservative therapy for six months before operative resection is resorted to. Coccygectomy resulted in complete relief from coccygeal pain in only 74 per cent. of the cases, but this procedure is recommended when conservative treatment has failed. The article contains a good statistical analysis.—*I. William Nachlas, M.D., Baltimore, Maryland.*

ANOMALIE SCHELETRICHE SINGOLARI IN UN FETO OTTIMESTRE (Unique Skeletal Anomalies in an Eight-Months-Old Foetus). Riccardo Galeazzi. *Archivio di Ortopedia*, LII, 369, 1936.

A stillborn female foetus at the end of the eighth month revealed skeletal anomalies which have not been described in the literature. The main feature was the abnormal shortness of the extremities. Ossification had occurred only in the radii, the tibiae, and the terminal phalanges of the fingers and the toes. All of the other bones had remained

cartilaginous without any trace of osteogenesis. The base of the skull was likewise underdeveloped and entirely cartilaginous. Only three vertebral bodies of the thoracolumbar junction showed small centers of ossification; the bones with membranous origin, however, were normally developed. Galeazzi traces the origin of the anomaly to the earliest stages of embryonic life. The pathogenesis is obscure, but Galeazzi suspects an alteration of the precartilaginous blastema and believes that such anomalies belong to the group of phocomelia.—*Ernst Freund, M.D., Los Angeles, California.*

L'ARTRORISI NELLA CURA DELLA DEFORMITÀ TALOCRURALE CONGENITA DI VOLKMANN (Arthroereisis in the Treatment of Volkmann's Congenital Ankle Deformity). Riccardo Galeazzi. *Archivio di Ortopedica*, LII, 391, 1936.

Volkmann's deformity may be due to an underdevelopment of the fibula, or to a backward displacement of the outer malleolus, or to a combination of both factors. In all such cases, Galeazzi uses a corrective procedure which consists mainly of an arthroereisis of the ankle joint, in which the fibula is used as a bone block. The outer malleolus is brought into its physiological position, or the fibula is osteotomized and the lower fragment is displaced downward and forward to form a normal external malleolus. In the more severe case, in which the child has walked for several years with the foot in a position of marked valgus, changes occur in the joint line of the tibiotarsal articulation. Galeazzi performs an osteotomy of the tibia above the joint, brings the lower joint end into correct alignment, and fills the resulting defect with bone taken from the tibia at a higher level. Illustrations show the satisfactory results obtained with the operative procedure.—*Ernst Freund, M.D., Los Angeles, California.*

L'OSTEOTOMIA CURVILINEA A CERNIERA NELLA CURA DI DIVERSE DEFORMITÀ OSSEE ED ARTICOLARI (The Curved Hinge Osteotomy in the Treatment of Various Deformities of Bones and Joints). Luigi de Gaetano. *Archivio di Ortopedia*, LII, 405, 1936.

Gaetano thinks that this form of osteotomy has not found the wide application which it deserves. The osteotomy can be performed with a special saw (Alessandri) or with curved and straight chisels. The advantages which this operation has over straight and wedge-shaped osteotomies are emphasized and the different parts of the skeleton to which the procedure can be applied are discussed. Rachitic deformities of the long bones are the main indication. Knee-joint deformities rank next, usually necessitating supracondylar osteotomies.—*Ernst Freund, M.D., Los Angeles, California.*

CONSIDERAZIONI SOPRA UN CASO DI MALFORMAZIONE CONGENITA DELLA MANO (A Case of Congenital Malformation of the Hand). Giulio Cardi. *Archivio di Ortopedia*, LII, 427, 1936.

The author reports a case of a male, sixteen years of age, with a family history of finger anomalies. Examination showed a deformed left hand with syndactylism of the first phalanges of the third and fourth fingers which had a common third metacarpal. The fourth metacarpal bone was hypoplastic. Cardi believes that such deformities are due to an arrest of or an aberration in the growth of the embryonic tags from which the extremities later develop.—*Ernst Freund, M.D., Los Angeles, California.*

UN CASO RARO DI EMIMELIA (A Rare Case of Hemimelia). Arnumgiato Caratozzolo. *Archivio di Ortopedia*, LII, 435, 1936.

The author reports the case of a seven-year-old girl with a short stump of a forearm. At the end of the stump were four small fingers without a skeleton, merely cutaneous appendages. The thumb was absent.—*Ernst Freund, M.D., Los Angeles, California.*

CONTRIBUTO ALLO STUDIO DELL'OSTEOGENESI IMPERFECTA (Contribution to the Study of Osteogenesis Imperfecta). L. Racugno. *Archivio di Ortopedia*, LII, 441, 1936.

Following a review of the literature on etiology, pathogenesis, and physiopathology of osteogenesis imperfecta, two cases are reported, one of which was hereditary. The differential diagnosis and treatment are discussed.—*Ernst Freund, M.D., Los Angeles, California.*

SULLE FRATTURE DELLA COLONNA VERTEBRALE (CON PARTICOLARE RIGUARDO ALLA DIAGNOSI RADIOLOGICA, ALLA EVOLUZIONE ED AGLI ESITI A DISTANZA). [Fracture of the Vertebral Column (with Particular Regard to the Roentgenographic Diagnosis, the Course, and the End Result).] Carlo Schapira. *Archivio di Ortopedia*, LII, 465, 1936.

This long and interesting article gives a statistical report on 105 cases of fracture of the spine observed at the *Istituto Ortopedico Toscano* from 1926 to 1936. The more interesting cases are discussed in detail, especially those of fracture of the cervical spine and of the odontoid process, and the end results are given. The roentgenographic picture of fracture of the thoracic spine is discussed in detail, and the differential diagnosis is considered. Attention is paid to the behavior of the intervertebral discs in cases of fracture of the vertebral bodies, and cases are mentioned in which severe trauma to the spine was followed only by rupture of the vertebral disc. The problem of the unrecognized fracture of the spine is considered, and the important question concerning localized deforming spondylarthritis and fracture of the vertebral body is answered with the assumption that localized hypertrophic changes are due to callus formation rather than to arthritis. Kümmel's traumatic spondylitis has not been observed by the author. He thinks that such cases are either unrecognized fractures of the vertebral body or quite often cases of Pott's disease. As far as treatment is concerned, Schapira advocates Böhler's active treatment with reduction and exercises, but discusses also at length the method of Magnus.—*Ernst Freund, M.D., Los Angeles, California.*

FIXATION OF THE HIP-JOINT BY MEANS OF AN EXTRA-ARTICULAR BONE-GRAFT: LATE RESULTS. Hugh C. Trumble. *The British Journal of Surgery*, XXIV, 728, 1937.

This is a report of cases operated on by a method described in 1932, in which a bone graft is placed between the ischium and the shaft of the femur, below the level of the lesser trochanter. The operation was carried out on eight patients with tuberculous hip joints. The grafts united satisfactorily in seven patients. In three instances sinuses to the hip joint healed after the fusion. There was no primary or secondary sepsis in the operative wounds. Fracture of the graft occurred in one case eighteen months after operation.

THE TREATMENT OF FRACTURED PATELLA BY EXCISION. A STUDY OF MORPHOLOGY AND FUNCTION. R. Brooke. *The British Journal of Surgery*, XXIV, 733, 1937.

Complete removal of the patella as a treatment for fracture of the patella is recommended. This is certainly radical treatment, but the author produces results that warrant the new method.

From the standpoint of comparative anatomy it is evident that the patella is a vestigeal structure and that function does not influence its development and growth. In slowly moving animals the patella is massive and well developed, while in rapidly moving animals it is small. Developmentally, the bone forms behind the quadriceps tendon and becomes attached to it secondarily, but it does not develop within the tendon.

Experimental work on the cadaver, with the patella in place and then removed, has been carried out. By a system of pulleys and recording drums it has been shown that extension of the lower leg through a right angle took place more rapidly without the patella and that there was less resistance to a weight applied against the moving force.

The writer has removed the patellar fragments *in toto* from thirty patients. He does not give results on all his cases, but in ten instances he has made end-result studies

which show, with one exception, that the injured member is stronger in resisting flexion than the uninjured one. Recovery takes place in two to three weeks and laboring men return to ladder-climbing in six weeks.

The operation is done forty-eight hours after injury. The bone fragments are shelled out through a vertical incision. The article is illustrated by photographs of patients following operation.

A Note on the Extension Apparatus of the Knee-Joint. Ernest W. Hey Groves. *The British Journal of Surgery*, XXIV, 747, 1937.

Hey Groves states that he has personally examined eight of Brooke's patients and feels that all claims made for the operation are justified. He has made anatomical studies which convince him that the quadriceps tendon merely passes over the patella. He believes that in operating on a fractured patella the important part of the operation is the suture of the lateral expansions of the quadriceps tendon. He is convinced that when the patella is removed a much closer and firmer repair of the torn tendon can be made.

Psychological Factors in Rheumatism. A Preliminary Study. James L. Halliday. *British Medical Journal*, I, 213, 264; 1937.

The author presents a regional analysis of the part played by psychological factors in bringing about such symptoms as pain, stiffness and limitation of movement. He emphasizes that these symptoms, in the absence of organic change, are often erroneously called rheumatism or fibrositis, neuritis, sciatica, lumbago, and so forth, and are commonly treated by physical therapy. Frequently the illness in which the symptoms emerge is much better understood and treated by regarding the complaint as a manifestation of a chronic psychoneurotic state in which the "rheumatism" occurs merely as an episode. This is based upon behavior patterns or instincts which drive the individual to behave as a human being. The conflict of these instincts with the individual's environment may provoke a reaction of illness which belongs to two groups: First, environmental factors which the individual meets by direct contact of his body tissue; second, those factors which frustrate or threaten to frustrate the instincts that drive the individual. Physicians can greatly increase their understanding of illness by realizing that when the instincts are frustrated emotion is manifested. By means of this mechanism, psychological factors may profoundly affect the individual. With the passage of time, the bodily disturbances resulting from emotional reaction may subside, or one or more of the disturbances may be maintained in the original or modified form. For example, in the respiratory system, choking and sobs may merge into asthma, while in the locomotor system, the soreness and stiffness which the patient may have experienced between paroxysms of grief is translated into "rheumatism". Pain may be an expression of inferiority, inherited or acquired. Acquired inferiority may be physical, or mental in the form of knowledge and fear.

The author considers in some detail how a particular site may be chosen for pain. This is usually due to the fact that the patient considers a particular body site as "inferior", either in a physical or in a mental state; or else a symptom may be attached to a part of the body by a mechanism known as symbolization. For example, pain in the low back in the absence of structural change may mean that the individual's pride has been hurt, as exhibited in persons who through unemployment are compelled to take up an occupation which is beneath them. This point is further developed by histories of patients who have suffered from "rheumatism", with inability to move a joint, but who have shown no organic lesion.

In his discussion of prevention and treatment, the writer stresses the fact that adequate therapy depends on recognition of the true nature of the patient's disorder and on knowing how not to make the patient worse. Such recognition requires a thorough physical examination, an appreciation of the part which psychological factors play in affecting the body, and, finally, the refraining from discovering structural abnormalities

which are not there. The knowledge of how not to injure the patient necessitates an understanding of the three main characteristics of psychoneurotic illness, — innocence and rationalization, increased suggestibility, and motive and purpose.

This is an excellent paper. It is well worth detailed study.—*G. E. Haggart, M.D., Boston, Massachusetts.*

LA MALADIE DE KÖHLER DU SCAPHOÏDE TARSIEN (KÖHLER'S DISEASE OF THE TARSAL SCAPHOID). Willy Smets. *Bulletin de la Société Belge d'Orthopédie*, VII, 65, 1936.

From a clinical study and a survey of the literature, Smets (Brussels) believes that the so-called Köhler's disease of the tarsal scaphoid is simply a normal variation in ossification. This conclusion is based on the following observations: (1) The lesion is usually bilateral; (2) there are no clinical signs in the majority of cases and it is simply an incidental roentgenographic finding; (3) so-called healing occurs spontaneously; (4) one can usually find alterations in ossification of a similar nature in other parts of the body; (5) there is a familial tendency to this abnormality, which is shown particularly well in twins, a fact observed by Camerer. At times, as the author shows in a case described in detail, this "paranormal ossification" is a generalized phenomenon.—*John J. Kuhns, M.D., Boston, Massachusetts.*

SYNDROME HÉRÉDITAIRE (Hereditary Syndrome). R. Montant et A. Eggermann. *La Presse Médicale*, XLV, 770, 1937.

The authors give the general history of a family in which ten instances of a hereditary disease were observed. The condition is characterized by hypoplasia of the patella and malformation of the head of the radius, which leads to dislocation of the head of the radius and limitation of pronation and supination, with a hemiatrophy of the cubital half of the thumbnail. The symptoms are found only in blonde, blue-eyed individuals, though not all the blonde, blue-eyed individuals are affected. The condition is apparently dominant; it is not sex-linked, and, because of its preponderance, is believed to be due to a single gene.—*Henry Milch, M.D., New York, N. Y.*

LA MALADIE DE PELLEGRINI-STIEDA (Pellegrini-Stieda Disease). L. Sabadini. *La Presse Médicale*, XLV, 797, 1937.

The author is of the opinion that Pellegrini-Stieda disease is a true molecular fracture at the femoral attachment of the tibial ligament. Even in those cases where roentgenograms taken immediately after the alleged injury show no gross fragments, the author believes that the fracture is still present, but so small as not to show on the print. He believes the symptoms are due invariably to tension on the tibial collateral ligament during the action of flexion, hyperadduction, and external rotation of the leg. In its first phase, the condition is characterized by localized tenderness and localized swelling at the epicondyle of the femur. Stiffness and interference with flexion are present, but there is never any intra-articular fluid. A roentgenogram taken in this first stage often shows a paracondylar shadow. Following the acute injury there is a latent period during which the patient complains of a slight limp, and pain on flexion. Then, gradually and progressively, the third stage, the so-called characteristic Pellegrini-Stieda disease, is initiated by pain, functional limitation, especially flexion, and gradual development of a paracondylar osteoma.

In the first stage, treatment consists of rest, immobilization on a plaster splint and local infiltration with novocain. Massage is, of course, completely contra-indicated. In the later stage, operative intervention for the removal of the calcific mass may be undertaken, provided repeated roentgenograms show that the process of calcification has reached the end stage.—*Henry Milch, M.D., New York, N. Y.*

ROENTGENTHÉRAPIE DE L'ARTHRITE BLENNORRAGIQUE (Roentgenotherapy of Gonorrhoeal Arthritis). Nguyen-Dinh-Hoang. *La Presse Médicale*, XLV, 895, 1937.

Nine cases of gonorrhoeal arthritis, involving various joints of the body, are reported. All seem to show definite relief from pain after roentgenotherapy. The author is of the opinion that this treatment is indicated both in the acute and in the chronic phases of the disease. Even in the frankly purulent forms, the severity of the affliction may be minimized by the use of x-ray therapy. In the acute cases, the dosage should be lower than in the chronic cases. Details of the technique are furnished in the article. In the acute and subacute stages careful judgment must be used to avoid lighting up the process. The author believes that as a result of stimulation of phagocytosis, bactericidal action, proteolysis, stimulation of the circulation and modification of the pH, roentgenotherapy permits amelioration of the pain, with earlier and more complete restoration of function.

—*Henry Milch, M.D., New York, N. Y.*

DES DOULEURS PROVOQUÉES PAR L'EXCITATION DU BOUT CENTRAL DES GRANDS SPLANCHNIQUES (Reflex Pains from Stimulation of the Central Ends of the Cut Splanchnic Nerves). René Leriche. *La Presse Médicale*, XLV, 971, June 30, 1937.

During the course of the past few years twenty-one sections of the splanchnic nerve have been performed for different indications. Usually these operations have been performed under general anaesthesia, but, recently, the author has been using spinal anaesthesia. In two such cases, while the greater splanchnic nerves were being cut slowly, the patient suddenly complained of severe pain in the thoracic region. When the left splanchnic was cut, the patient complained of pain in the cremasteric region; when the right was cut, in the pulmonary region. This pain was immediately relieved by injection of novocain into the cut nerves. On the basis of these observations the author suggests that anginal pain noted after a heavy meal may be reflex and circulatory in nature and connected with irritation of the splanchnic nerves.

The communication is extremely interesting and stimulating, and offers new vistas for clinical observation.—*Henry Milch, M.D., New York, N. Y.*

RESTAURATION DU POUCE PAR POLLICISATION DU DEUXIÈME MÉTACARPIEN (Restoration of the Thumb by "Pollicisation" of the Second Metacarpal). Marc Iselin et Jean Murat. *La Presse Médicale*, XLV, 1099, July 28, 1937.

The authors call attention to the fact that the efforts at restoration of the thumb may be divided in general into two types: First, the so-called methods of phalangization, recommended by the French school, and, second, the methods of reconstruction of the thumb by grafting, recommended by the Austrian school. The authors favor utilization of the second, in place of the first metacarpal. In principle, the operation consists of maintenance of the nervous, vascular, and muscular structures of the second finger, while at the same time placing the finger in the position of opposition. This is done mainly by osteotomy of the metacarpal, but involves, as auxiliary problems, the making of the web, the treatment of the stump of the injured thumb, etc.

The details of this operation are not described, since they are to appear in a forthcoming article.

A number of very interesting photographs, illustrating the end results, are presented, as well as the outlines of two case histories.—*Henry Milch, M.D., New York, N. Y.*

ÉTUDE STATISTIQUE SUR L'ÉTIOLOGIE DE LA MÉNINGITE TUBERCULEUSE (Statistical Study of the Etiology of Tuberculous Meningitis). Pierre Nobécourt et Sotirios B. Briskas. *La Presse Médicale*, XLV, 1131, August 4, 1937.

Following their larger studies on the appearance of tuberculosis in children, recently published, the authors interested themselves in the study of tuberculous meningitis. Of 13,331 children up to the age of fourteen years and eleven months, seen between the years 1921 and 1925, 344 cases, or 2.5 per cent., were found to have tuberculous meningitis.

Tuberculous meningitis is seen infrequently between the ages of three and twelve months; never seen before three months, and reaches its maximum frequency of over 6 per cent. at about the age of five years, after which it gradually declines. It attacks boys and girls equally and seems to appear more commonly in the spring and summer than in the fall. This probably represents not a true seasonal variation, but a variation dependent upon the number of children hospitalized during the respective months.—*Henry Milch, M.D., New York, N. Y.*

TECHNIQUE SIMPLIFIÉE POUR L'ARTHRODÈSE EXTRA-ARTICULAIRE DE LA HANCHE PAR GREFFON TIBIAL DANS LA COXALGIE TYPE 37 (Simplified Technique for Extra-Arthrodesis of the Hip by Means of Tibial Graft). H. L. Rocher. *Journal de Médecine de Bordeaux et du Sud-Ouest*, CXIV, 69, 1937.

The author recommends a modification of Massart's type of arthrodesis of the hip. The typical anterior Smith-Petersen incision is made and then a longitudinal external lateral incision is made over the greater trochanter. A hole is drilled over the base of the greater trochanter, emerging at the upper surface of the neck. The capsule is not opened. A bed is gouged in the side of the ilium, and a tibial graft is passed through the drilled hole in the trochanter and buried in the ilium. The limb is then immobilized in plaster.

The author calls this arthrodesis "Type 37" and recommends it particularly for extra-articular fusions in cases of tuberculosis.—*Henry Milch, M.D., New York, N Y.*

HEREDITARY MULTIPLE ANKYLOSING ARTHROPATHY (Congenital Stiffness of the Finger Joints). A. R. Bloom. *Radiology*, XXIX, 166, 1937.

Investigation of the various cases reported proves that this anomaly is inherited according to Mendel's law. There is never ankylosis at birth. It starts in childhood and early youth, and becomes more marked as the subject grows older. At any one time various stages can be seen in various joints, up to solid bony union. The fingers are never alone involved, the condition commonly affecting also metatarsals, head of the radius, and lumbar vertebrae. One case is reported. In this case practically all the tarsal bones were fused into one solid mass.—*Edward N. Reed, M.D., Santa Monica, California.*

THE END RESULTS OF INJURIES TO THE EPIPHYSES. Oscar Lipschultz. *Radiology*, XXVIII, 223, 1937.

This paper attempts to answer the question, "Does premature ossification or deformity result from traumatic displacement of epiphyses?" One hundred and six cases of such epiphyseal displacement were followed up for from sixteen months to eight years, the epiphyses involved being those at the lower end of the radius, ulna, tibia, and fibula, the upper end of the humerus, the medial epicondyle, lateral epicondyle, and lesser trochanter of the femur.

Premature ossification, with changes in growth, took place in 14 per cent. of the cases. While the amount of shortening is usually minimal, it is occasionally marked, resulting in deformity and disturbance of function.

Perfect reduction does not ensure against marked interference with growth, nor is failure of reduction necessarily followed by marked disturbance.—*Edward N. Reed, M.D., Santa Monica, California.*

FRACTURE DISLOCATION OF THE UPPER END OF THE HUMERUS. Guy W. Leadbetter. *Southern Medical Journal*, XXX, 433, April 1937.

This is a report on seventeen cases. Such fracture-dislocations usually occur after severe trauma which may be caused by automobile accidents or falls from a height. Two of the cases were treated satisfactorily by suspension traction, with gentle manipula-

tion from day to day. Ten cases were reduced, with fluoroscopic control, by means of strong traction and digital manipulation. Five cases were treated by open operation; in one of these the head was completely removed and a weak, unsatisfactory shoulder resulted. Two of these patients died, both were syphilitics. Plaster fixation was usually used after reduction except in traction cases. The author found that in the cases reduced by manipulation the results were better, and the patients remained in the hospital a shorter time. Open operation is difficult and causes considerable trauma and permanent damage to the joint. Early reduction is important. Even a week of delay increases the difficulty of reduction.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

ADAMANTINOMA OF THE TIBIA. E. L. Bishop. *Southern Medical Journal*, XXX, 571, June 1937.

Adamantinoma is the specific tumor arising from the enamel of the teeth. Extramaxillary adamantinomata are rare. The case which the author describes is believed to be the fifth case so far reported,—three in foreign literature, and now two in this country. The tumor occurred in the upper end of the tibia. One and a half years previously, the patient had sustained a fracture in this region. On removal of the cast, eight weeks later, there was a swelling in this area, but he was able to go hunting. Roentgenographic examination showed a multilocular cystic area which was diagnosed as a multiple bone cyst or giant-cell tumor. The area was curetted and filled with bone chips and two tibial grafts. The diagnosis of material removed was "adenocarcinoma". Sixteen months later, roentgenograms showed that there was absorption of bone chips and graft, and that the tumor had involved the soft tissues. Amputation was performed. Sections from many areas of the tissue showed typical structure of adamantinoma. There has been no recurrence or metastasis.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

ARTHRODESIS OF THE KNEE WITH A LARGE CENTRAL AUTOGENOUS BONE PEG. J. Albert Key. *Southern Medical Journal*, XXX, 574, June 1937.

In this operation, after removal of the cartilaginous surfaces of the tibia and femur, a large graft is removed from the crest of the tibia through a separate incision. This graft is driven up into the shaft of the femur between the condyles for about two inches, then wedged into the upper end of the tibia for about the same distance. The tibia and femur are then forced together, the wound is closed, and a plaster spica is applied. The advantages claimed are that the peg stabilizes the knee while plaster is being applied, prevents motion between the bones, and hastens firm bony ankylosis. It is not used in children because injury to the epiphyses would prevent growth.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

VENOUS STASIS ACCELERATES BONE REPAIR. Herman E. Pearse, Jr., and John J. Morton. *Surgery*, I, 106, Jan. 1937.

As Key and Walton had questioned their previously published experimental evidence, Pearse and Morton repeated their work on the effect of venous stasis on bone repair. In twenty-eight experiments, in which bilateral resection of three to four millimeters of dogs' fibulae was performed, repair was found to be accelerated on the side of ligation of the popliteal vein in 90 per cent. of the cases. They reviewed the experimental evidence as presented by other authors and concluded that venous stasis does accelerate bone repair.

UNUNITED FRACTURE OF THE NECK OF THE FEMUR. Willis C. Campbell. *Surgery*, I, 499, Apr. 1937.

After discussing the various theories as to the cause of non-union of fractures of the neck of the femur, the pathology was reviewed. The author feels that Santos was cor-

rect, and that in some instances the head is viable, in others it is dead and acts as a sequestrum. The treatment depends on various factors, including the age and general condition of the patient and the viability of the head of the femur. He reports seventy-five cases in which some operative work has been done for non-union. In thirty-six of them, a tibial bone graft was used, with solid union resulting in twenty cases. There was one death among these patients, and eight operations were considered failures. Results in seven cases are not known, or it is too early for the final results to be determined. This operation he considers the ideal procedure, as perfect anatomical restoration is possible.

In thirty-five cases in which some type of reconstruction operation was performed (Whitman, Albee, Brackett, or a modification of these), there were fourteen with excellent results; eight were failures; there was one death; and in twelve the result is unknown.

Osteotomy was done in four cases. In one there was an excellent result; the others are too recent to estimate.

ZUR WIEDERHERSTELLUNGS-CHIRURGIE DES KNIEGELENKES (Restorative Surgery of the Knee Joint). Arnold Wittek. *Wiener klinische Wochenschrift*, L, 803, 1937.

This article presents several outstanding points derived from a survey of over 1100 operations on the knee joint in a country where winter sports and football make the subject one of constant general interest. Sudden hyperextension of the knee in skiing may stretch or tear the anterior cruciate ligament and permit not only anterior displacement of the tibia on the femur but also an abnormal lateral mobility in the manner of a genu valgum. Few such injuries ever heal by immobilization in a cast; conservative treatment may succeed only when there is overstretching and not avulsion of the ligament. Healing of the torn ligament depends on the integrity of an artery that enters it from the popliteal space. Therefore, Wittek bases his operations on the restoration of blood supply from this source. Although there sometimes occurs spontaneous reformation of previously destroyed cruciate ligaments, one way in which he achieves this revascularization is to unite the intact posterior cruciate ligament to an attached tibial fragment of the anterior ligament.

In cases in which the medial meniscus is loosened also, Wittek substitutes the meniscus for the anterior cruciate ligament by attaching its posterior end to the posterior cruciate ligament after additional fixation of the anteromedial rim of the meniscus to the cartilage of the medial tibial condyle. The anterior end of the medial meniscus may also be drawn through an artificial intercondylar tibial canal. When a strip of patellar tendon is used similarly, the lower end of the strip retains its continuity with the rest of the patellar tendon.

Where there is injury to the cruciate ligament combined with injury to the medial lateral ligament, Wittek exposes the joint by chiseling off a portion of the medial femoral epicondyle and turning it down with a triangular portion of the capsule. After repair of the internal ligaments the separated epicondyle is nailed into a new bed proximal to its original position. This effectively restores the support lost by the stretching and laceration of the medial lateral ligament.

Such operations assume serious responsibility on the surgeon's part and are to be undertaken only after unsuccessful trial of conservative measures or when operation is definitely indicated. Although danger of occasional infection exists, Wittek reports a series of 600 operations on cruciate and meniscus ligaments without a single instance of infection.—*O. Theodore Roberg, Jr., M.D., Chicago, Illinois.*

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